This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

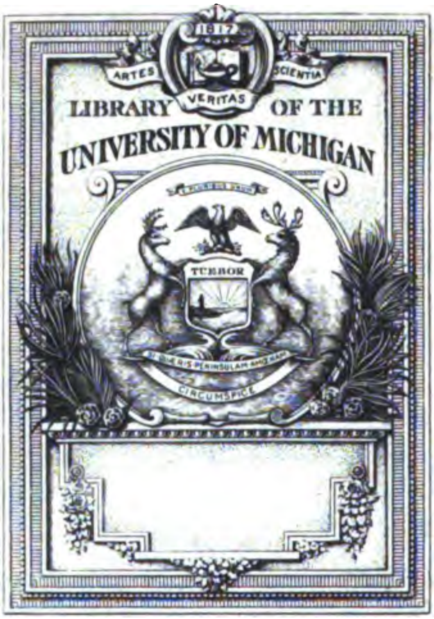
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



LIBRARY OF THE UNIVERSITY OF MICHIGAN

THE GIFT OF
Tappan Presb.Assoc.

BT
100
.I43
1786

1817
ARTES VERITAS SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

THE GIFT OF
Tappan Presb. Assoc.

BT
100
.I43
1786

DERHAM(s)

PHYSICO AND ASTRO THEOLOGY:

OR, A

DEMONSTRATION

OF

The Being and Attributes of God.

A NEW EDITION

IN TWO VOLUMES.

VOLUME I.

LONDON:
PRINTED AT THE Logographic Press, BY J. WALTER,
AND SOLD BY J. RIVINGTON AND SONS, ST. PAUL'S CHURCH YARD;
J. ROBSON, NEW BOND-STREET; AND J. SEWELL, CORNHILL.
MDCCLXXXVI.

573.

270. 1011

PHYSICO-THEOLOGY,

OR, A

DEMONSTRATION

OF

The Being and Attributes of God,

FROM HIS

WORKS OF CREATION.

Being the Subſtance of SIXTEEN SERMONS, Preached in
St. MARY-LE-BOW-CHURCH, LONDON; at the Hon. Mr.
BOYLE's LECTURES, in the Years 1711, and 1712.
With large Notes and many curious Obſervations.

By W. DERHAM, D. D. late Canon of WINDSOR,
Rector of UPMINSTER in ESSEX, and F. R. S.

MALA ET IMPIA CONSUETUDO EST CONTRA DEOS DISPUTARE, SIVE
ANIMO ID FIAT, SIVE SIMULATE. Cic. de Nat. Deor. L. 2. fine.

MDCCLXXXVI.

Gift
Tappan Presb. Ass
4-9-1932

TO

The moſt Reverend Father in GOD,

THOMAS,

Lord Archbiſhop of *Canterbury*,
Primate of all ENGLAND, &c.

The Surviving TRUSTEE of the Honourable
Mr. BOYLE's LECTURES.

May it pleaſe your GRACE,

I MAY juſtly put theſe LECTURES under your Grace's patronage, their publication being wholly owing to you: for having the honour to be a member of the Royal Society, as well as a divine, I was minded to try what I could do towards the improvement of philoſophical matters to theological uſes; and accordingly laid a ſcheme of what I have here publiſhed a part of; and when I had little elſe to do, I drew up what I had to ſay, making it rather the diverting ex-

exerciſes

erciſes of my leiſure hours than more ſerious theological ſtudies. This work, although I made a conſiderable progreſs in it at firſt, whilſt a novelty, yet, having no thoughts of publiſhing, I laid aſide, untill your Grace, being informed of my deſign by ſome of my learned friends, both of the clergy and laity, was pleaſed to call me to the unexpected honour of preaching Mr. Boyle's Lectures: an honour I was little aware of in my country-privacy, and not much acquainted with perſons in high ſtations, and not at all, particularly, with your Grace. So that therefore, as it pleaſed your Grace, not only to confer an unſought profitable honour upon me, a ſtranger, but alſo to continue it for two years, out of your good opinion of my performance, in ſome meaſure, anſwering Mr. Boyle's end; ſo I can do no leſs than make this public, grateful acknowledgement of your Grace's great and unexpected favour.

But it is not myſelf alone; but the whole Lecture alſo is beholden to your Grace's kind and pious endeavours. It was you that encouraged this noble charity, and aſſiſted in the ſettlement of it, in the honourable founder's life time; and ſince his death, it was you that procured a more certain ſalary for the Lecturers, paid more conſtantly and duly than it was before.*

---

* It may not only gratify the reader's curioſity, but alſo be of uſe for preventing encroachments in time to come, to give the following account of Mr. Boyle's Lectures.

Mr. Boyle, by a codicil, dated July the 28th, 1691, and annexed to his will, charged his meſſuage or dwelling-houſe, in St. Michael's Crooked-Lane, London, with the payment of the clear yearly rents and profits thereof, to ſome learned divine in London, or within the Bills of mortality, to be elected for a term not exceeding three years, by his Grace the preſent Lord Archbiſhop of Canterbury, then Dr. Teniſon, Sir Henry Aſhurſt, Sir John Rotheram, and John Evelyn, Eſq. The buſineſs he appointed thoſe lectures for, was, among others, 'To be ready to ſatisfy real ſcruples, and 'to anſwer ſuch new objections and difficulties, as might be ſtarted, 'to which good anſwers had not been made.' And alſo, 'To 'preach eight ſermons in the year, viz. the firſt Monday of January, 'Febuary, March, April, and May; and of September, October, 'and November.' The ſubiect of theſe ſermons was to be, 'The 'proof of the Chriſtian religion againſt notorious infidels, viz. 'Atheiſts, Theiſts, Pagans, Jews, and Mahometans; not deſcend-'ing lower to any controverſies that are among Chriſtians them-'ſelves.' But by reaſon the lecturers were ſeldom continued above a year, and that the houſe ſometimes ſtood empty, and tenants brake, or failed in due payment of their rent, therefore the ſalary ſometimes remained long unpaid, or could not be gotten without ſome difficulty: to remedy which inconvenience, his preſent Grace of Canterbury procured a yearly ſtipend of 50l. to be paid quarterly for ever, charged upon a farm in the pariſh of Brill, in the county of Bucks: which ſtipend is accordingly very duly paid, when demanded, without fee or reward.

Theſe benefits, as I myſelf have been a ſharer of, ſo I ſhould be very ungrateful, ſhould I not duly acknowledge, and repay with my repeated thanks and good wiſhes. And that the infinite Rewarder of well-doing, may give your Grace a plentiful reward of theſe, and your many other, both public and private benefactions, is the hearty wiſh of

Your GRACE'S

Moſt humble and thankful

Son and Servant,

W. DERHAM.

TO THE

READER.

AS the noble founder of the Lectures I have had the honour of preaching, was a great improver af natural knowledge, ſo, in all probability, he did it out of a pious end, as well as in purſuit of his genius. For it was his ſettled opinion, that nothing tended more to cultivate true religion and piety in a man's mind, than a thorough ſkill in philoſophy. And ſuch effect it manifeſtly had in him, as is evident from divers of his publiſhed pieces; from his conſtant deportment in never mentioning the name of God without a pauſe, and viſible ſtop in his diſcourſe; and from the noble foundation of his lectures for the honour of God, and the generous ſtipend he allowed for the ſame,

Vid. Bp. Burnet's funeral ſermon, page 24.

AND foraſmuch as his lectures were appointed by him for the proof of the Chriſtian religion againſt Atheiſts and other notorious infidels, I thought, when I had the honour to be made his lecturer, that I could not better come up to his intent, than to attempt a demonſtration of the being and attributes of God, in what I may call Mr. Boyle's own, that is, a phyſico-theological way. And, beſides that, as it was for this very ſervice that I was called to this honour, I was the more induced

Vid. Mr. Boyle's Will.

induced to follow this method, by reaſon none of my learned and ingenious predeceſſors in theſe lectures, have done it on purpoſe, but only caſually, in a tranſient, piece-meal-manner: they having made it their buſineſs to prove the great points of Chriſtianity in another way, which they have accordingly admirably done. But conſidering what our honourable founder's opinion was of natural knowledge, and that his intent was, that thoſe matters, by paſſing through divers hands, and by being treated of in different methods, ſhould take in moſt of what could be ſaid upon the ſubject; I hope my performance may be acceptable, although one of the meaneſt.

As for others, who have before me done ſomething of this kind; as Merſenne, on Geneſis; Dr. Cockburn, in his Eſſays; Mr. Ray, in his Wiſdom of God, &c. and I may add the firſt of Mr. Boyle's Lecturers, the moſt learned Dr. Bentley, in his Boyle's Lectures, the eloquent archbiſhop of Cambray, (and I hear the ingenious Monſieur Perault hath ſomething of this kind, but never ſaw it:) I ſay, as to theſe learned and ingenious authors, as the creation is an ample ſubject, ſo I induſtriouſly endeavoured to avoid doing over again what they before had done: and for that reaſon did not, for many years, read their books, until I had finiſhed my own. But when I came to compare what each of us had done, I found myſelf in many things to have been anticipated by ſome or other of them, eſpecially by my friend, the late great Mr. Ray. And therefore in ſome places I ſhortened my diſcourſe, and referred to them; and in a few others, where the thread of my diſcourſe would have been interrupted, I have made uſe of their authority, as the beſt judges; as of Mr. Ray's, for inſtance, with relation to the mountains, and their plants, and other products. If then the reader ſhould meet with any thing mentioned before by others, and not accordingly acknowledged by me, I hope he will candidly think me no plagiary, becauſe I can aſſure him I have all along, where I was aware of it, cited my authors, with their due praiſe. And it is ſcarce poſſible, when men write on the ſame, or a ſubject near a-kin, and the obſervations are obvious, but that they muſt often hit upon the ſame thing: and frequently this may happen from perſons making obſervations about one, and the ſame thing, without knowing what each other hath done; which indeed, when the firſt edition of my book was nearly printed off, I found to be my own caſe, having (for want of Dr. Hook's Micrography being at hand, it being a very ſcarce book, and many years ſince I read it,) given deſcriptions of two or three things, which I thought had not been tolerably well obſerved before, but are deſcribed well by that curious gentleman.

One is a feather, the mechaniſm of which we in the main agree in, except in his repreſentation in fig. 1. ſcheme 22, which is ſomewhat different from what I have repreſented in my fig. 18, &c. But I can ſtand by the truth, though not the elegance of my figures. But as to the other differences, they are accidental, occaſioned by our taking the parts in a different view, or in a different part of a vane; and to ſay the truth, (not flattering myſelf, or detracting from the admirable obſervations of that great man,) I have hit upon a few things that eſcaped him, being enabled to do ſo, not only by the help of ſuch microſcopes as he made uſe of; but alſo by thoſe made by Mr. Wilſon, which exceed all I ever ſaw, whether of Engliſh, Dutch, or Italian make; ſeveral of which ſorts I have ſeen and examined.

The other thing we have both of us figured and deſcribed is, the ſting of a bee or waſp; in which we differ more than in the laſt. But by a careful re-examination, I find, that although Dr. Hook's obſervations are more critical than any were before, yet they are not ſo true as mine. For as to the ſcabbard, as he calls it, I could never diſcover any beards thereon; and I dare be confident there are none, but what are on the two ſpears. And as to the point of the ſcabbard, he hath repreſented it as tubular, or bluntiſh at the top; but it realy terminates in a ſharp point, and the two ſpears and the poiſon come out of a ſlit, or longiſh hole, a little below the top or point. And as to the ſpears, he makes them to be but one, and that the point thereof lies always out of the ſcabbard. But by a ſtrict examination, they will be found to be two, as I have ſaid, and that they always lie within the ſcabbard, except in ſtinging; as I have repreſented them in fig. 21. from the tranſparent ſting of a waſp. And as to the ſpear being made of joints, and parted into two, as his fig. 2, ſcheme 16. repreſents, I could never upon a review diſcover it to be ſo, but imagine, that by ſeeing the beards lying upon, or behind the ſpears, he might take them for joints, and by ſeeing the point of one ſpear lie before the other, he might think the ſpear was parted in two. But leſt the reader ſhould think himſelf impoſed upon by Dr. Hook, and myſelf, it is neceſſary to be obſerved, that the beards, or tenterhooks, as Dr. Hook calls them, lie only on one ſide of each ſpear, not all round them; and are therefore not to be ſeen, unleſs they are laid in a due poſture in the microſcope, *viz.* ſideways, not under, or a top the ſpear.

The laſt thing, which ſcarce deſerves mention, is the mechaniſm of the hair, which Dr. Hook found to be ſolid, like a long piece of horn, not hollow, as Malpighi found it in ſome animals. And I have found both thoſe great men to be in ſome meaſure in the right, the hair of ſome animals, or in ſome parts of the body, being very little, if at all tubular: and in others, particularly mice, rats, and cats, to be as I have repreſented in my fig. 14, &c.

And now if my inadvertency in other things hath no worſe effect than it hath had in theſe, namely, to confirm, correct, or clear others obſervations, I hope the reader will excuſe it, if he meets with any more of the like kind. But not being conſcious of any ſuch thing, although probably there may be many ſuch, I am more ſolicitous to beg the reader's candour and favour, with relation both to the text and notes: in the former of which, I fear he will think I have as much under-done, as in the latter over-done, the matter: but for my excuſe, I deſire it may be conſidered, that the textual part being ſermons, to be delivered in the pulpit, it was neceſſary to inſiſt but briefly upon many of the works of God, and to leave out many things that might have been admitted in a more free diſcourſe. So that I wiſh it may not be thought I have ſaid too much, rather than too little, for ſuch an occaſion and place. And indeed, I had no ſmall trouble in expounding ſome things, altering many, and ſoftening the moſt, and, in a word, giving, in ſome meaſure, the whole, a different dreſs than what I had at firſt drawn it up in, and what it now appears in.

And as for the notes, which may be thought too large, I confeſs I might have ſhortened them, and had thoughts of doing it, by caſting ſome of them into the text, as an ingenious learned friend adviſed. But when I began to do this, I found it was in a manner to new-make all, and that I ſhould be neceſſitated to tranſcribe the greateſt part of the book, which, having no aſſiſtant, would have been too tedious for me, being pretty well fatigued with it before. I then thought it beſt to pare off from ſome, and to leave out others, and accordingly did ſo in many places, and would have done it in more, particularly, in many of the citations out of the ancients, both poets and others, as alſo in many of the anatomical obſervations, and many of my own and others obſervations; but then I conſidered, as to the firſt, that thoſe citations do, many of them at leaſt, ſhew the ſenſe of mankind about God's works, and that the moſt of them may be acceptable to young gentlemen at the univerſities, for whoſe ſervice theſe lectures are greatly intended. And as to the anatomical notes, and ſome others of the like nature, moſt of them ſerve either to the confirmation, or the illuſtration, or explication of the text, if not to the learned, yet to the unſkilful, leſs learned reader; for whoſe ſake, if I had added more, I believe he would forgive me. And laſtly, as to the obſervaions of myſelf, and ſome others, where it happen that they are long, it is commonly where a neceſſity lay upon me of fully expreſſing the author's ſenſe, or my own, or where the thing was new, and never before publiſhed: in which caſe, it was neceſſary to be more expreſs and particular, than in matters better known, or where the author may be referred unto.

In the former editions I promiſed another part I had relating to the heavens, if I was thereunto encouraged. And two large impreſſions of this book having been ſold off, ſo as to admit of a third before the year was gone about; and hearing that it is tranſlated into two, if not three languages; but eſpecially being importuned by divers learned perſons, both known and unknown, I have thought myſelf ſufficiently engaged to perform that promiſe; and have accordingly publiſhed that part.

So that I have now carried my ſurvey through moſt parts of the viſible creation, except the waters, which are for the moſt part omitted: and the vegetables, which, for want of time, I was forced to treat of in a perfunctory manner. And to the underſtanding of the former of theſe, having received divers ſolicitations from perſons unknown, as well as known, I think myſelf bound in civility to own their favour, and to return them my hearty thanks for the kind opinion they have ſhewn of my other performances, that they have encouraged me to undertake this other taſk. And accordingly I have begun it, and, as far as my affairs will permit, have made ſome progreſs in it: but age and avocations growing upon me, I begin to fear I ſhall ſcarce be able to finiſh it as I would, and therefore muſt recommend that ample and noble ſubject to others, who have more leiſure, and would do it better than I.

As to additions, I have been much ſolicited thereunto by divers curious and learned perſons, who would have had me to inſert ſome of their obſervations, and many more of my own: but in a work of this nature, this would have been endleſs: and although the book would thereby be rendered much better, and more complete, yet I could by no means excuſe ſo great an injuſtice to the purchaſers of the former editions. And therefore, except in the ſecond edition, where it was not eaſy to be avoided, few additions or alterations have been made, beſides what were typographical, or of ſmall conſideration. Only in the third edition I amended the firſt paragraph of note 1, chap. 5. book 1. concerning gravity: and in the fourth, page 21 and 23, I inſerted two paſſages out of Seneca, that were inadvertently left out, and corrected many things, that upon a careful review, ſeemed to want amendment.

CONTENTS.

OF VOL. I.

page

A Survey of the Terraqueous Globe.

Introduction, 1

BOOK I.

Of the out-works of the Terraqueous Globe; the Atmoſphere, Light, and Gravity. 5

CHAP. I. *Of the atmoſphere in general.* ibid.

——— II. *Of the winds.* 18

———III. *Of the clouds and rain.* 26

——— IV. *Of light.* 35

——— V. *Of gravity.* 42

BOOK II.

Of the Terraqueous Globe itſelf in general 50

CHAP. I. *Of the figure of the terraqueous globe.* 53

——— II. *Of the bulk of the terraqueous globe.* 58

———III. *Of the motions of the terraqueous globe:* 59

——— IV. *Of the place and ſituation of the terraqueous globe, in reſpect of the heavenly bodies.* 63

——— V. *Of the diſtribution of the earth and waters.* 64

———VI. *Of the great variety and quantity of all things upon, and in the terraqueous globe, provided for the uſes of the world.* 72

BOOK III.

Of the Terraqueous Globe in particular, more eſpecially the Earth. 81

CHAP. I. *Of the ſoils and moulds in the earth.* 83

——— II. *Of the various ſtrata, or beds, obſervable in the earth.* 84

CONTENTS.

page
CHAP. III. *Of the ſubterraneous caverns and vulcanos.* 91
—— IV. *Of the mountains and valleys.* 97
The concluſion. 113

BOOK IV.

Of Animals in general. 116
CHAP. I. *Of the five ſenſes in general.* 118
—— II. *Of the eye.* 121
—— III. *Of the ſenſe of hearing.* 158
—— *Of ſound.* 179
—— IV. *Of the ſenſe of ſmelling.* 190
—— V. *Of the taſte.* 195
—— VI. *Of the ſenſe of feeling.* 199
—— VII. *Of reſpiration.* 203
—— VIII. *Of the motion of animals.* 222
—— IX. *Of the place allotted to the ſeveral tribes of animals.* 234
—— X. *Of the ballance of animals, or the due proportion in which the world is ſtocked with them.* 238
—— XI. *Of the food of animals.* 254
—— *Of animals mouths.* 269
—— *Of animals ſtomachs.* 281
—— *Of animals ſagacity to get food.* 288
—— *Of animals care of their young.* 295
—— *The concluſion.* 303
—— XII. *Of the clothing of animals.* 306
—— XIII. *Of the houſes and habitations of animals* 328
—— XIV. *Of animals ſelf-preſervation.* 339
—— XV. *Of the generation of animals.* 347
—— XVI. *The concluſion.* 366

CONTENTS.

BOOK V.

Page

A Survey of the particular Tribes of Animals. 369

A ſurvey of man ibid·

CHAP. I. *Of the ſoul of man.* 371

——— *Of man's inclinations.* 373

——— *Of man's invention.* 373

——— II. *Of man's body, particularly its poſture.* 398

——— III. *Of the figure and ſhape of man's body.* 406

——— IV. *Of the ſtature and ſize of man's body.* 407

——— V. *Of the ſtructure of the parts of man's body.* 414

——— VI. *Of the placing of the parts of man's body.* 419

——— VII. *Of the proviſion in man's body againſt evils* 423

——— VIII. *Of the conſent between the parts of man's body.* 431

——— IX. *Of the variety of mens faces, voices, and hand-writing.* 435

——— X. *The concluſion of the ſurvey of man.* 440

A
SURVEY
OF THE
TERRAQUEOUS GLOBE.

INTRODUCTION.

IN Pſal cxi. 2. the pſalmiſt aſſerts, that '[a] works of the Lord are great; ſought out of all them that have pleaſure therein.'

THIS is true of all God's works, particularly of his works of creation: which, when ſought out; or as the Hebrew word[b] ſignifieth, when heedfully

---

[a] It is not unlikely that the pſalmiſt might mean; at leaſt have an eye to, the works of creation in this text, the word מעשה, being the ſame that in Pſal. xix. 1. is tranſlated God's handy-work, which is manifeſtly applied to the works of creation, and properly ſignifieth 'factum, opus, opificium,' from עשה, fecit paravit, aptavit.' And, ſaith Kircher 'Significat talem affectionem, qua aliquid exiſtit vel realiter, vel ornate, vel ut non ſit in priſtino ſtatu quo fuit.' Concord. p. 2. col. 931.

[b] דרש 'Quæſivit, perquiſivit, ſciſcitatus eſt.' Buxtor. in ver. 'Et ſimul importat curam, et ſolicitudinem.' Conrad. Kirch. ib. p. 1. col. 1174.

fully and deeply pryed into, ſolicitouſly obſerved and inquired out, eſpecially when clearly diſcovered to us; in this caſe, I ſay, we find thoſe works of God abundantly to deſerve the pſalmiſt's character of being great and noble; inaſmuch, as they are made with the moſt exquiſite art, [c] contrived with the utmoſt ſagacity, and ordered with a plain wiſe deſign, and miniſtring to admirable ends [d]. For which reaſon St. Paul might well affirm of thoſe Ποίηματα of God that the ‘ inviſible things of God, even his eternal power and ‘ Godhead, are underſtood by them.’ And indeed they are the moſt eaſy, and intelligible demonſtrations of the being and attributes of God; [e] eſpecially to ſuch as are unacquainted with the ſubtilties of reaſoning and argumentation; as the greateſt part of mankind are.

---

[c] 'Quod ſi omnes mundi partes ita conſtitutæ ſunt, ut neque ad uſum meliores potuerint eſſe, neque ad ſpecient pulchriores; videamus utrum ea fortuita ſint, an eo ſtatu, quo coherere nullo modo potuerint, niſi ſenſu moderante divinaque providentia. Si ergo meliora ſunt ea quæ natura, quam illa, quæ arte perfecta ſunt, nec ars efficit quid ſine ratione; ne natura quidem rationis expers eſt habenda. Qui igitur convenit, ſignum, aut tabulam pictam cum adſpexeris, ſcire adhibitam eſſe artem; cumque procul curſum navigii videris, non dubitare, quin id ratione atque arte moveatur: aut cum ſolarium &c. mundem autem, qui et has ipſas artes, et earum artifices, et cuncta complectatur, conſilii et rationis eſſe expertem putare; quod ſi in Scythiam, aut in Britanniam, ſphæram aliquis tulerit hanc, quam nuper familiaris noſter effecit Poſidonius, cujus ſingulæ converſiones idem efficiunt in ſole, &c.——quod efficitur in cœlo ſingulis diebus et noctibus; quis in illa barbarie dubitet, quin ea ſphæra ſit perfecta ratione? hi autem dubitant de mundo, ex quo et oriuntur, et fiunt omnia, caſu ne ipſe ſit effectus,——an ratione, an mente divina; et Archimedem arbitrantur plus valuiſſe in imitandis ſphæræ converſionibus, quam naturam in efficiendis, præſertim cum multis partibus ſint illa perfecta, quam hæc ſimulata, ſolertius, &c.' Cic. de Nat. l. 2, c. 34, 35.

It may not therefore be unſuitable to the nature and deſign of lectures [f] founded by one of the greateſt virtuoſos of the laſt age, and inſtituted too on purpoſe for the proof of the Chriſtian religion againſt Atheiſts, and other infidels, to improve this occaſion in the demonſtration of the being and attributes of an infinitely wiſe and powerful Creator, from a curſory ſurvey of the works of creation or, as often called, of nature.

---

[d] And a little before he ſaith of nature itſelf, ‘ Omnem ‘ ergo regit naturam ipſe [Deus] &c.’

[e] ‘ Mundus codex eſt Dei, in quo jugiter legere debemus. Bernard. Serm.

‘ Arbitror nullam gentem, neque hominum ſocietatem, a‘ pud quos ulla Deorum eſt religio, quidquam habere ſacras ‘ Eleuſiniis aut Samothraciis ſimile: ea tamen obſcure docent ‘ quæ profitentur: naturæ vero opera in omnibus animantibus ‘ ſunt perſpicua.’ Galen. de Uſ. Part. I. 17. c. 1.

[f] ‘ Philoſophia eſt catechiſmus ad fidem.’ Cyril. I. contr. Jul.

WHICH works belong either to our terraqueous globe, or the heavens

I SHALL begin with our own globe, being neareſt, and falling moſt under our ſenſes. Which being a ſubject very various and copious, for the more methodical and orderly proceeding upon it, I ſhall diſtribute the works therein,

I. INTO ſuch as are not properly parts, but appendages or out-works of the globe

II. THE globe itſelf.

B O O K I.

OF THE OUT-WORKS OF THE TERRAQUEOUS GLOBE, THE ATMOSPHERE, LIGHT, AND GRAVITY.

C H A P. I.

OF THE ATMOSPHERE IN GENERAL.

THE atmoſphere, or maſs of air, vapours and clouds, which ſurrounds our globe, will appear to be a matter of deſign, and the infinitely wiſe Creator's work, if we conſider its nature and make [g], and its uſe to the world [h].

1. Its nature and make, a maſs of air, of ſubtil penetrating matter, fit to pervade other bodies, to penetrate into the inmoſt receſſes of nature, to excite, animate, and ſpiritualize; and, in ſhort, to be the very ſoul of this lower world. A thing conſequently 2.

---

[g] 'Mundi pars eſt aër et quidem neceſſaria: hic eſt enim 'qui cœlum terramque connectit, &c.' Senec. Nat. Qu. l. 2. c. 4.

[h] 'Ipſe aer nobiſcum videt, nobiſcum audit nobiſcum ſonat; nihil enim eorum ſine eo fieri poteſt, &c.' Cic. de Nat. Deor. l. 2. c. 33.

2. Of greateſt uſe to the world, uſeful to the life, the health, the comfort, the pleaſure, and buſineſs of the whole globe. It is the air the whole animal world breatheth, and liveth by; not only the animals inhabiting the earth [i] and

---

[i] As the air is of abſolute neceſſity to animal life, ſo it is neceſſary that it ſhould be of a due temperament or conſiſtence; not foul, by reaſon, that ſuffocateth; not too rare and thin, becauſe that ſufficeth not: with examples of each of which, I ſhall a little entertain the reader. In one of Mr. Hawkſbee's compreſſing engines, I cloſely ſhut up a ſparrow, without forcing any air in; and in leſs than an hour the bird began to pant, and be concerned; and in leſs than an hour and half to be ſick, vomit and more out of breath, and in two hours time was nearly expiring.

Another I put in and compreſſed the air, but the engine leaking, I frequently renewed the compreſſure; by which means, (although the bird panted a little after the firſt hour) yet after ſuch frequent compreſſures, and immiſſion of freſh air, it was very little concerned, and taken out ſeemingly unhurt after three hours.

After this I made two other experiments in compreſſed air; with the weight of two Atmoſpheres injected, the engine holding tight and well; the one with the great titmouſe, the other with a ſparrow. For near an hour they ſeemed but little concerned; but after that grew fainter, and in two hours time ſick, and in three hour's time died. Another thing I took notice of, was, that when the birds were ſick, and very reſtleſs, I fancied they were ſomewhat relieved for a ſhort ſpace, with the motion of the air, cauſed by their fluttering and ſhaking their wings, (a thing worth trying in the diving Bell.) I ſhall leave the ingenious reader to judge what the cauſe was of both the birds living longer in compreſſed, than uncompreſſed, air; whether a leſs quantity of air was not ſooner fouled and rendered unfit for reſpiration, than a greater.

From theſe experiments two things are manifeſted; one is, that air, in ſome meaſure compreſſed, or rather heavy, is neceſſary to animal life: of which by and by. The other, that freſh air is alſo neceſſary; for pent up air, when overcharged with the vapours emitted out of the animal's body becomes unfit for reſpiration. For which reaſon in the diving-bell, after ſome time of ſtay under water, they are forced to come up and take in freſh air, or by ſome ſuch means recruit it. But the famous Cornelius Drebell contrived not only a veſſel to be rowed under water, but alſo a liquor to be carried in that veſſel, that would ſupply the want of freſh air. The veſſel was made for King James I. It carried twelve rowers, beſides the paſſengers. It was tried in the river of Thames; and one of the perſons that was in that ſubmarine navigation was then alive, and told it one, who related the matter to our famous founder, the honourable and moſt ingenious Mr. Boyle. As to the liquor, Mr. Boyle ſaith, he diſcovered by a doctor of phyſic, who married Drebell's daughter, that it was uſed from time to time, when the air, in the ſubmarine boat, was clogged by the breath of the company, and thereby made unfit for reſpiration; at which time, by unſtopping a veſſel full of this liquor, he could ſpeedily reſtore to the troubled air ſuch a proportion of vital parts, as would make it again for a good while fit for reſpiration. The ſecret of this liquor Drebell would never diſcloſe to above one perſon, who himſelf aſſured Mr. Boyle what it was. Vide Boyle's Exp. Phyſ. Mech. of the Spring of the air, Exp 41. in the digreſſion. This ſtory I have related from Mr. Boyle, but at the ſame time much queſtion, whither the virtues of the liquor were ſo effectual as reported.

And as too groſs, ſo too rare an air is unfit for reſpiration. Not to mention the forced refractions made by the air-pump, in the following note; it is found, that even the extraordinary natural rarefactions, upon the tops of very high hills, much af-ſect reſpiration. An eccleſiaſtical perſon, who had viſited the high mountains of Armenia, on which ſome fancy the ark reſted, told Mr. Boyle, that whilſt he was on the upper part of them, he was forced to fetch his breath oftener than he was wont: and taking notice of it when he came down, the people told him, that it was what happened to them, when they were ſo high above the plain, and that it was a common obſervation among them. The like obſervation the ſame eccleſiaſtic made upon the top of a mountain in the Cevennes. So a learned traveller, and curious perſon, on one of the higheſt ridges of the Pyrenees, called Pic de Midi, found the air not ſo fit for reſpiration, as the common air, but he and his company were fain to breathe ſhorter and oftener than in the lower air. Vide. Phil. Tranſact. No. 63, or Lowthorp's Abridg. Vol. 2, p. 226.

SUCH another relation, the learned Joſeph Acoſta gives of himſelf, and his company, that, when they paſſed the high mountains of Peru, which they call Periacaca, (to which he ſaith, 'the Alps themſelves, ſeemed to them but as ordinary 'houſes, in regard of high towers,) he, and his companions, 'were ſurprized with ſuch extreme pangs of ſtraining, and vo'miting, not without caſting up of blood too, and with ſo vio'lent a diſtemper, that he concludes he ſhould undoubtedly 'have died; but that this laſted not above three or four hours, 'before they came into a more convenient and natural tempe'rature of the air.' All which he concludes, proceeded from the too great ſubtilty and delicacy of the air, which is not proportionable to human reſpiration, which requires a more groſs and temperate air. Vide Boyle, ubi ſupra.

THUS it appears, that an air too ſubtil, rare and light, is unfit for reſpiration: but the cauſe is not the ſubtilty, or too great delicacy, as Mr. Boyle thinks, but the too great lightneſs thereof, which renders it unable to be a counterbalance, or an antagoniſt to the heart, and all the muſcles miniſtering to reſpiration, and the diaſtole of the heart. Of which ſee book 4, chap. 7,

AND

air [j] but thoſe of the waters too [k]. Without

it

AND as our inability to live in too rare and light an air, may diſcourage thoſe vain attempts of flying, and whimſies of paſſing to the moon, &c. ſo our being able to bear an heavier ſtate of the air is an excellent proviſion for men's occaſions in mines, and other great depths of the earth; and thoſe other greater preſſures made upon the air, in the diving bell, when we deſcend into great depths of the waters.

[j] THAT the inhabitants of the air, birds and inſects, need the air as well as man, and other animals, is manifeſt from their ſpeedy dying in too feculent, or too much rarified air; of which ſee the preceding and following note *a*. But yet birds and inſects, ſome birds at leaſt, can live in a rarer air than man. Thus eagles, kites, herons, and divers other birds, that delight in high flights, are not affected with the rarity of the medium, as thoſe perſons were in the preceding note *a*. So inſects bear the air pump long, as in the following note *a*.

[k] CREATURES inhabiting the waters, need the air, as well as other animals, yea, and freſh air too. The hydrocanthari of all ſorts, the nymphæ of gnats, and many other water inſects, have a ſingular faculty, and an admirable apparatus, to raiſe their back-parts to the top of the waters, and take in freſh air. It is pretty to ſee, for inſtance, the hydrocanthari come and thurſt their tails out of the water, and take in a bubble of air, at the tip of their vaginæ and tails, and then nimbly carry it down with them into the waters; and when that is ſpent, or fouled, to aſcend again and recruit it.

So fiſhes alſo are well known to uſe reſpiration, by paſſing the water through their mouths and gills. But carps will live out of the water, only in the air; as is manifeſt by the experiment of their way of fatting them in Holland, and which has been practiſed here in England; viz. they hang them up

in

it moſt animals live ſcarce half a minute [1]; and others

in a cellar, or ſome cool place, in wet moſs in a ſmall net, with their heads out, and feed them with white bread ſoaked in milk, for many days. This was told me by a perſon very curious, and of great honour and eminence, whoſe word, if I had leave to name him, no body would queſtion: and it being an inſtance of the reſpiration of fiſhes very ſingular and ſomewhat out of the way, I have for the reader's diverſion taken notice of it.

[1] By experiments I made myſelf in the air-pump in September and October, 1704, I obſerved that animals whoſe hearts have two ventricles, and no foramen ovale, as birds, dogs, cats, rats, mice, &c. die in leſs than half a minute, counting from the very firſt exſuction; eſpecially in a ſmall receiver.

A MOLE (which I ſuſpected might have borne more than other quadrupeds) died in one minute, without recovery, in a large receiver; and doubtleſs would hardly have ſurvived half a minute in a ſmall receiver. A bat, although wounded, ſuſtained the pump two minutes, and revived upon the re-admiſſion of the air. After that, he remained four minutes and a half, and revived. Laſtly, after he had been five minutes, he continued gaſping for a time, and after twenty minutes I re-admitted the air, but the bat never revived.

As for inſects; waſps, bees, hornets, graſhoppers, and lady-cows, ſeemed dead in appearance in two minutes, but revived in the open air in two or three hours time, notwithſtanding they had been in vacuo twenty four hours.

THE ear-wig, the great ſtaphylinus, the great black lowſy beetle, and ſome other inſects would ſeem unconcerned at the vacuum a good while, and lie as dead; but revive in the air, although ſome had lain ſixteen hours in the exhauſted receiver.

SNAILS

others that are the moſt accuſtomed to the want of it, live not without it many days.

AND not only animals themſelves, but even trees and plants, and the whole vegetable race, owe their vegetation and life to this uſeful element; as will appear when I come to ſpeak of them, and is manifeſt from their glory and verdure in a free air, and their becoming pale and ſickly, and languiſhing and dying, when by any means excluded from it [m].

THUS

SNAILS bear the air-pump prodigiouſly, eſpecially thoſe in ſhells; two of which lay above twenty four hours, and ſeemed not much affected. The ſame ſnails I left in twenty eight hours more after a ſecond exhauſtion, and found one of them quite dead, but the other revived.

FROGS and toads bear the pump long, eſpecially the former. A large toad, found in the houſe, died irrecoverably in leſs than ſix hours. Another toad and frog I put in together, and the toad was ſeemingly dead in two hours, but the frog juſt alive. After they had remained there eleven hours, and ſeemingly dead, the frog recovered in the open air, only weak, but the toad was quite dead. The ſame frog being put in again for twenty ſeven hours then quite died.

THE animalcules in pepper-water, remained in vacuo twenty four hours: And after they had been expoſed a day or two to the open air, I found ſome of them dead, ſome alive.

[m] THAT the air is the principal cauſe of the vegetation of plants, Borelli proves, in his excellent book, De Mot. Animal. vol. 2. prop. 181. And in the next propoſition, he aſſureth, ‘ In plantis quoque peragi æris reſpirationem quandam im-

‘ perfectam

Thus uſeful, thus neceſſary, is the air to the life of the animated creatures; and no leſs is it to the motion and conveyance of many of them. All the winged tribes owe their flight and buoyancy [a] to it, as ſhall be ſhewn in a proper place: And even the watery inhabitants themſelves cannot aſcend and deſcend into their element well without it [o].

But

'perfectam, aqua earum vita pendet, et conſervatur.' But of this more, when I come to ſurvey vegetables.

'Some lettice ſeed being ſown upon ſome earth in the open 'air, and ſome of the ſame ſeed, at the ſame time, upon other 'earth in a glaſs-receiver of the pneumatic engine, afterwards 'exhauſted of air: the ſeed expoſed to the air, was grown up an 'inch and half high within eight days; but that in the exhauſted 'receiver not at all. And air being again admitted into the ſame 'emptied receiver, to ſee whether any of the ſeed would then come 'up, it was found, that in the ſpace of one week, it was grown 'up to the height of two or three inches.' Vide Phil. Tranſ. No. 23. Lowth. Abridg. vol. 2. p. 206.

[a] 'In volucribus pulmones perforati ærem inſpiratum in 'totam ventris cavitatem admittunt. Hujus ratio, ut propter 'corporis truncum ære repletum et quaſi extenſum, ipſa magis 'volatilia evadant, faciliuſque ab ære externo, propter intimi 'penum, ſuſtententur. Equidem piſces, quo levius in aquis 'natent, in abdomine veſicas ære inflatas geſtant: pariter et vol'ucres, propter corporis truncum ære impletum et quaſi inflatum, 'nudo æri incumbentes, minus gravantur, proindeque levius et 'expeditius volant.' Willis de Anim. Brut. p. 1. c. 3.

[o] 'Fishes, by reaſon of the bladder of air within them, cannot 'ſuſtain, or keep themſelves in any depth of water: for the air

'in

But it would be tedious to deſcend too far into particulars, to reckon up the many benefits of this noble appendage of our globe in many uſe-
ful

' in that bladder being more or leſs compreſſed, according to the
' depth the fiſh ſwims at, takes up more or leſs ſpace; and con-
' ſequently the body of the fiſh, part of whoſe bulk this bladder
' is, is greater or leſs, according to the ſeveral depths, and yet
' retains the ſame weight. Now, the rule *de inſidentibus humido* is,
' that a body that is heavier than ſo much water, as is equal in
' quantity to the bulk of it, will ſink; a body that is lighter will
' ſwim: a body of equal weight will reſt in any part of the water.
' By this rule, if the fiſh, in the middle region of the water, be of
' equal weight to the water, that is, commenſurate to the bulk of it,
' the fiſh, will reſt there, without any tendency upwards or down-
' wards: and if the fiſh be deeper in the water, the bulk of the fiſh
' becoming leſs by the compreſſion of the bladder, and yet
' retaining the ſame weight, it will ſink, and reſt at the bottom.
' And on the other ſide, if the fiſh be higher than the middle
' region, the air dilating itſelf, and the bulk of the fiſh con
' ſequently increaſing, but not the weight, the fiſh will riſe up-
' wards, and reſt at the top of the water. Perhaps, the fiſh
' by ſome action can emit air out of its bladder:——and, when
' not enough, take in air,——and then it will not be wondered,
' that there ſhould be always a fit proportion of air, in all fiſhes
' to ſerve their uſe.' &c. Then follows a method of Mr. Boyle's
to experiment the truth of this. After which, in Mr. Low-
thorp's abridgement, follow Mr. Ray's obſervations. ' I think
' that ——hath hit upon the true uſe of the ſwimming-bladders
' in fiſhes. For 1. It hath been obſerved, that, if the ſwim-
' ming-bladder of any fiſh, be pricked or broken, ſuch a fiſh
' ſinks preſently to the bottom, and can neither ſupport or raiſe
' itſelf up in the water. 2. Flat fiſhes, as ſoles, place, &c. which
lie always grovelling at the bottom, have no ſwimming-bladders
' that ever I could find. 3. In moſt fiſhes there is a manifeſt
' channel leading from the gullet—to the ſaid bladder, which
' without

ful engine[p]; in many of the functions and operations of nature[r] in the conveyance of ſounds; and a thouſand things beſides. And I ſhall but juſt mention the admirable uſe of our Atmoſphere

in

' without doubt, ſerves for the conveying air thereunto.———— ' in the coat of this bladder, is a muſculous power to contract it ' it when the fiſh liſts.' See more very curious obſervations, relating to this matter, of the late great Mr. Ray, as alſo of the curious anonymous gentleman, in the ingenious Mr. Lowthorp's abridgement beforecited, p. 845, from Philoſoph. Tranſ. No. 114. 115.

[p] AMONG the engines in which the air is uſeful, pumps may be accounted not contemptible ones, and divers other hydraulical engines, which need not to be particularly inſiſted on, In theſe the water was imagined to riſe by the power of ſuction, to avoid a vacuum, and ſuch unintelligible ſtuff; but the juſtly famous Mr. Boyle, was the firſt that ſolved theſe phænomena by the weight of the atmoſphere. His ingenious and curious obſervations and experiments relating thereto, may be ſeen in his little tract, of the cauſe of attraction by ſuction, and divers others of his tracts,

[r] IT would be endleſs to ſpecify the uſes of air in nature's operations: I ſhall therefore for a ſample only, name its great uſe to the world in conſerving animated bodies, whether endowed with animal or vegetative life, and its contrary quality of diſſolving other bodies; by which means, many bodies that would prove nuiſances to the world, are put out of the way, by being reduced into their firſt principles, as we ſay, and ſo embodied with the earth again. Of its faculty as a menſtruum, or its power to diſſolve bodies, I may inſtance in cryſtal glaſſes: which with long keeping, eſpecially if not uſed, will in time, be reduced to a powder, as I have ſeen. So divers minerals, earths, ſtones, foſſil-ſhells, wood, etc. which from Noah's flood, at leaſt for manys ages have lain under ground, ſo ſecure from corruption, that on the contrary, they have been thereby made much the ſtronger, have in the open air ſoon mouldered away.

Of

In miniſtring to the enlightening of the world, by its reflecting the light of the heavenly bodies to us [f]; and refracting the ſun-beams to our eye, before

---

Of which laſt, Mr. Boyle gives an inſtance (from the Diſſertaion de admirandis Hungar. Aquis) of a great oak, like a huge beam, dug out of a ſalt-mine in Tranſilvania, 'ſo hard, that it would not eaſily be wrought upon by iron tools, yet, being expoſed to the air out of the mine, it became ſo rotten, that in four days it was eaſy to be broken, and crumbled between one's fingers.' Boyle's Suſpic. about ſome hidden qualities in the air, p. 28. So the trees turned out of the earth by the breaches at Weſt-Thurrock and Dagenham, near me, although probably no other than alder, and interred many ages ago in a rotten oazy mould, were ſo exceedingly tough, hard, and ſound at firſt, that I could make but little impreſſions on them with the ſtrokes of an ax; but being expoſed to the air and water ſoon became ſo rotten as to be crumbled between the fingers. See my obſervations in Philoſ. Tranſact. No 335.

[f] 'By reflecting the light of the heavenly bodies to us,' I mean that whiteneſs or lightneſs which is in the air in the day-time, cauſed by the rays of light ſtriking upon the particles of the atmoſphere, as well as upon the clouds above, and the other objects beneath upon the earth. To the ſame cauſe alſo we owe the twilight, viz. to the ſun beams touching the uppermoſt particles of our atmoſphere, which they do when the ſun is about eighteen degrees beneath the horizon. And as the beams reach more and more of the airy particles, ſo darkneſs goes off, and day-light comes on and increaſeth. For an exemplification of this, the experiment may ſerve of tranſmitting a few rays of the ſun through a ſmall hole into a dark room: by which means the rays which meet with duſt, and other particles flying in the air, are rendered viſible; or, which amounts to the ſame, thoſe ſwimming ſmall bodies are rendered viſible, by their reflecting the light of the ſun-beams to the eye, which, without ſuch reflection, would itſelf be inviſible.

before it ever ſurmounteth our horizon [t]; by which means the day is protracted throughout the whole globe; and the long and diſmal nights are ſhortened in the frigid zones, and day ſooner ap-

proacheth

The azure colour of the ſky Sir Iſaac Newton attributes to vapours beginning to condenſe, and that are not able to reflect the other colours. V. Optic. l. 2. par. 3. prop. 7.

[t] By the refractive power of the air, the ſun, and the other heavenly bodies ſeem higher than really they are, eſpecially near the horizon. What the refractions amount unto, what variations they have, and what alterations in time they cauſe, may be briefly ſeen in a little book called, The Artificial Clock-maker, chap. 11.

'Although this inflective quality of the air be a great incumbrance and confuſion of aſtronomical obſervations;—yet it is not without ſome conſiderable benefit to navigation; and indeed in ſome caſes, the benefit thereby obtained is much greater than would be the benefit of having the ray proceed in an exact ſtraight line,' [Then he mentions the benefit hereof to the polar parts of the world.] 'But this by the by (ſaith he.) The great advantage I conſider therein, is the firſt diſcovery of land upon the ſea; for by means hereof, the tops of hills and lands are raiſed up into the air, ſo as to be diſcoverable ſeveral leagues farther off on the ſea than they would be, were there no ſuch refraction, which is of great benefit to navigators for ſteering their courſes in the night, when they approach near land; and likewiſe for directing them in the day-time, much more certainly than the moſt exact celeſtial obſervations could do by the help of an uninflected ray, eſpecially in ſuch places as they have no ſoundings.' [Then he propoſes a method to find, by theſe means, the diſtance of objects at ſea.] V. Dr. Hook's Poſt. Works, Lect. of Nav. p. 466.

proacheth them; yea, the ſun itſelf riſeth in appearance (when really it is abſent from them) to the great comfort of thoſe forlorn places [u].

But paſſing by all theſe things with only a bare mention, and wholly omitting others that might have been named, I ſhall only inſiſt upon the excellent uſe of this noble circumambient companion of our globe, in reſpect of two of its meteors, the winds, and the clouds and rain [v].

---

[u] 'Cum Belgæ in nova Zembla hybernarent, ſol illis paparuit 16 diebus citius quam revera in horizonte exiſteret, hoc 'eſt, cum adhuc infra horizontem depreſſus eſſet quatuor circiter gradibus, et quidem aere ſereno.' Var. Geog. c. 19. pro. 22.

[These Hollanders] 'found that the night in that place 'ſhortened no leſs than a whole month; which muſt needs be 'a very great comfort to all ſuch places as live very far towards 'the north and ſouth poles, where length of night, and want of 'ſeeing the ſun, cannot chuſe but be very tedious and irkſome.' Hook, ibid.

[By means of the refractions] 'we found the ſun to riſe twenty minutes before it ſhould; and in the evening to remain above the horizon twenty minutes, or thereabouts, longer than it 'ſhould.' Cap. James's Jour. in Boyle of cold. tit. 18. p. 190.

[v] 'Aer in nubes cogitur; humoremque colligens terram 'auget imbribus: tum effluens huc et illuc, ventos efficit. Idem 'annuas frigoram et calorum facit varietates: idemque et volatus alitum ſuſtinet, et ſpiritu ductus alit et ſuſtentat animantes.' Cic. de Nat. Deor. l. 2. c. 39.

CHAP. II.

Of the WINDS[w].

TO paſs by other conſiderations, whereby I might demonſtrate the winds to be the infinite Creator's contrivance, I ſhall inſiſt only upon their great uſefulneſs to the world. And ſo great is their uſe, and of ſuch abſolute neceſſity are they

---

[w] 'Ventus eſt ær fluens,' is Seneca's definition. Na. Qu. l. 5. AND as wind is a current of the air, ſo that which excites or alters its currents, may be juſtly ſaid to be the cauſe of the winds. An equipoiſe of the atmoſphere produceth a calm; but if that equipoiſe be more or leſs taken off, a ſtream of air, or wind, is thereby accordingly produced either ſtronger or weaker, ſwifter or ſlower. And divers things there are that may make ſuch alterations in the equipoiſe or balance of the atmoſphere, viz. eruptions of vapours from ſea or land; rarefractions and condenſations in one place more than another; the falling of rain, preſſure of the clouds, &c. Pliny, l. 9. a. 45. tells us of a certain cavern in Dalmatia, called Senta, 'in quem (ſaith he) dejecto levi pondere, quamvis tranquillo die, turbini ſimilis emicat procella.' But as to caves it is obſerved, that they often emit winds more or leſs. Dr. Connor, taking notice of this matter, ſpecifies theſe, 'In regno Neapolitano ex immani Cumanæ Sibyllæ antro tenuem ventum effluentem percepi.' The like he obſerved at the caves at Baia, and in ſome of the mines of Germany, and in the large ſalt-mines of Cracow in Poland. 'Ubi (ſaith he) opifices, et ipſe fodinæ dominus Andreas Morſtin, Nob. Polonus, mihi aſſeruerunt, quod tanta aliquando ventorum tempeſtas ex ambagioſis hujus fodinæ receſſibus ſurgere ſolebat, quod laborantes foſſores humi proſternebat, nec non portas et domicilia (quæ ſibi in hac fodina artifices extruunt) penitus evertebat.' Bern. Con. Diſ. Med. Phyſ. p. 33. art. 3.

AND as great caves, ſo great lakes ſometimes ſend forth winds.

So Gaſſendus ſaith the Lacus Legnius doth, ‘ E quo dum exoritur ‘ fumus, nubes haud dubie creanda eſt, quæ ſit brevi in tempeſtatem ſæviſſimam exoneranda,’ Gaſ. Vit. Peir. l. 5. p. 417.

BUT the moſt univerſal and conſtant alterations of the balance of the atmoſphere, are from heat and cold. This is manifeſt in the general trade-winds, blowing all the year between the tropics from eaſt to weſt: if the cauſe thereof be, as ſome ingenious men imagine, the ſun's daily progreſs round that part of the globe, and by his heat rarefying one part of the air, whilſt the cooler and heavier air behind preſſeth after. So the ſea and land breezes in note [a] p. 24. And ſo in our climate, the northerly and ſoutherly winds (commonly eſteemed the cauſes of cold and warm weather) are really the effects of the cold or warmth of the atmoſphere: of which I have had ſo many confirmations, that I have no doubt of it. As for inſtance, it is not uncommon to ſee a warm ſoutherly wind, ſuddenly changed to the north, by the fall of ſnow or hail; to ſee the wind in a froſty cold morning, north, and when the ſun hath well warmed the earth and air, you may obſerve it to wheel about toward the ſoutherly quarters; and again to turn northerly or eaſterly in the cold evening. It is from hence alſo, that in thunder-ſhowers the wind and clouds are oftentimes contrary to one another, eſpecially if hail falls, the ſultry weather below directing the wind one way, and the cold above the clouds another way. I took notice, upon March the 10th, 1710-11, (and divers ſuch like inſtances I have had before and ſince) that the morning was warm, and what wind ſtirred was weſt-ſouth-weſt, but the clouds were thick and black (as generally they are when ſnow enſues.) A little before noon the wind veered about to north by weſt, and ſometimes to other points, the clouds at the ſame time flying ſome north by weſt, ſome ſouth-weſt: about one of the clock it rained apace, the clouds flying ſometimes north-eaſt, then north, and at laſt both wind and clouds ſettled north by weſt; at which time ſleet fell plentifully, and to the ſalubrity of the atmoſphere, that all the world would be poiſoned without thoſe agitations thereof. We find how putrid, fœtid, and unfit for reſpiration, as well as health and pleaſure, a ſtagnating, confined, pent-up air is. And if the whole maſs of air and vapours was always at reſt, and without motion, inſtead of refreſhing and animating, it would ſuffocate, and poiſon all the world: but the perpetual commotions it receives from the gales and ſtorms, keep it pure and healthful [x].

Neither.

---

grew very cold. From all which I obſerve, 1. That although our region below was warm, the region of the clouds was cold, as the black, ſnowy clouds ſhewed. 2. That the ſtruggle between the warmth of ours, and the cold of the cloudy region, ſtopped the airy currents of both regions. 3. That the falling of the ſnow through our warmer air melted into rain at firſt; but that it became ſleet after the ſuperior cold had conquered the inferior warmth. 4. That, as that cold prevailed by degrees, ſo by degrees it wheeled about both the winds and clouds from the northwards towards the ſouth.

Hippocrates, l. 2. De Vict. Orat. ‘ Omnes ventos vel a nive, ‘ glacie, vehementi gelu, fluminibus, &c. ſpirare neceſſe judicat.’ Bartholin, de uſu Nivis, c. 1.

[x] ‘ It is well obſerved in my lord Howard's voyage to Con‘ſtantinople, that at Vienna they have frequent winds, which if ‘ they ceaſe long in ſummer, the plague often enſues: ſo that it is now ‘ grown into a proverb, that if Auſtria be not windy, it is ſubject ‘ to contagion.’ Bohun of Wind. p 213.

From ſome ſuch commotions of the air I imagine it is, that at Grand-Cairo the plague immediately ceaſes, as ſoon as the Nile begins

Neither are thoſe ventilations beneficial only to the health, but to the pleaſure alſo of the inhabitants of the terraqueous globe: witneſs the gales which fan us in the heat of ſummer; without which, even in this our temperate zone, men are ſcarce able to perform the labours of their calling, or not without danger of health and life [y].

But

---

begins to overflow; although Mr. Boyle attributes it to nitrous corpuſcles. Determ. Nat. of Effluv. chap. 4.

'Nulla enim propemodum regio eſt, quæ non habet aliquem flatum ex ſe naſcentem, et circa ſe cadentem.'

'Inter cætera itaque providentiæ opera, hoc quoque aliquis, ut 'dignum admiratione, ſuſpexerit. Non enim ex una cauſa, ventos aut 'invenit, aut per diverſa diſpoſuit: ſed primum ut æra non ſinerent pigreſcere, ſed aſſidua vexatione utilem redderent, vitalemque 'tracturis.' Sen. Nat. Quæſt. l. 5, c. 17, 18.

All this is more evident, from the cauſe aſſigned to malignant epidemical diſeaſes, particularly the plague, by my ingenious learned friend, Dr. Mead; and that is, an hot and moiſt temperament of the air, which is obſerved by Hippocrates, Galen, and the general hiſtories of epidemical diſeaſes, to attend thoſe diſtempers. Vide Mead of Poiſons, Eſſay 5. p. 161. But indeed, whether the cauſe be this, or poiſonous, malignant exhalations or animalcules, as others think, the winds are however very ſalutiferous in ſuch caſes, in cooling the air, and diſperſing and driving away the moiſt or peſtiferous vapours.

[y] July 8. 1707. (called, for ſome time after, the hot Tueſday) was ſo exceſſively hot and ſuffocating, by reaſon there was no wind ſtirring, that divers perſons died, or were in great danger of death, in their harveſt work. Particularly one who had formerly been my

ſervant

But eſpecially, witneſs the perpetual gales which throughout the whole year do fan the torrid zone, and make that climate an healthful and pleaſant habitation, which would otherwiſe be ſcarce habitable.

To

ſervant, a healthy, luſty, young man, was killed by the heat; and ſeveral horſes on the road dropped down and died the ſame day.

In the foregoing notes, having taken notice of ſome things relating to heat, although it be ſomewhat out of the way, I hope the reader will excuſe me, if I entertain him with ſome obſervations I have made about the heat of the air under the line, compared with the heat of our bodies. J. Patrick, who, as he is very accurate in making barometrical and thermometrical inſtruments, had the curioſity, for the nicer adjuſting his thermometers, to ſend two abroad (under the care of two very ſenſible ingenious men) one to the northern lat. of 81; the other to the parts under the equinoctial: in theſe two different climates, the places were marked where the the ſpirits ſtood at the ſevereſt cold and greateſt heat. And according to theſe obſervations he graduates his thermometers. With his ſtandard I compared my ſtandard thermometer, from all the degrees of cold, I could make with Sal Armoniac, &c. to the greateſt degrees of heat our thermometers would reach to. And with the ſame thermometer of mine, I experimented the greateſt heat of my body, in July, 1709. Firſt in an hot day without exerciſe, by putting the ball of my thermometer under my arm-pits, and other hotteſt parts of my body. By which means the ſpirits were raiſed 284 tenths of an inch above the ball. After that, in a much hotter day, and indeed nearly as hot as any day with us, and after I had heated myſelf with ſtrong exerciſe too, as much as I could well bear, I again tried the ſame experiment, but could not get the ſpirits above 288 tenths; which I thought an inconſiderable difference, for ſo ſeemingly a very different heat of my body. But from ſome

experiments

To theſe I might add many other great conveniences of the winds in various engines, and various buſineſſes. I might particularly inſiſt upon its great uſe to tranſport men to the fartheſt diſtant regions of the world[z]; and I might particularly ſpeak of the general and coaſting trade-winds the

---

experiments I have made (although I have unfortunately forgotten them) in very cold weather, I imagine the heat of an healthy body to be always much the ſame in the warmeſt parts thereof, both in ſummer and winter. Now between thoſe very degrees of 284, and 288, the point of the equatorial heat falleth. From which obſervaation it appears, that there is pretty nearly an equal contemperament of the warmth of our bodies, to that of the hotteſt part of the atmoſphere inhabited by us.

If the proportion of the degrees of heat be deſired from the freezing-point, to the winter, ſpring and ſummer air, the heat of man's body, of heated water, melted metals, and ſo to actual fire; an account may be met with of it, by my moſt ingenious friend, the great Sir Iſaac Newton, in Phil. Tranſact. No 270.

[z] ‘In hoc providentia ac diſpoſitor ille mundi Deus, æra ventis exercendum dedit,——non ut nos claſſes partem freti occupaturas compleremus milite armato, &c. Dedit illi ventos ad cuſtodiendam cœli terrarumque temperiem, ad evocandas ſupprimendaſque aquas, ad alendos ſatorum atque arborum fructus; quos ad maturitatem cum aliis cauſis adducit ipſa jactatio, attrahens cibum in ſumma, et ne torpeat, promovens, Dedit ventos ad ulteriora noſcenda: fuiſſet enim imperitum animal, et ſine magna experientia rerum homo, ſi circumſcriberetur natalis ſoli fine. Dedit ventos ut commoda cujuſque regionis fierent communia; non ut Legiones equitemque geſtarent nec ut pernicioſa gentibus arma tranſveherent,’ Seneca ibid.

the ſea and land-breezes [a]; the one ſerving to carry the mariner in long voyages from eaſt to weſt; the other ſerving to waft him to particular places; the one ſerving to carry him into his harbour, the other to bring him out. But I ſhould go too far to take notice of all particulars [b]. Leaving therefore

---

[a] 'Sea-breezes commonly riſe in the morning about nine 'o'clock.——They firſt approach the ſhore gently, as if they were 'afraid to come near it.——It comes in a fine, ſmall, black curl 'upon the water, whereas all the ſea between it and the ſhore, not 'yet reached by it, is as ſmooth and even as glaſs in compariſon. 'In half an hour's time after it has reached the ſhore, it fans pretty 'briſkly, and ſo increaſeth gradually till twelve o'clock; then it is 'commonly the ſtrongeſt, and laſts ſo till two or three, a very 'briſk gale.—After three it begins to die away again, and gradually 'withdraws its force till all is ſpent; and about five o'clock—it is 'lulled aſleep, and comes no more till next morning,

'And as the ſea-breezes do blow in the day, and reſt in the night, 'ſo on the contrary [the land-breezes] blow in the night, and reſt 'in the day, alternately ſucceeding each other.——They ſpring up 'between ſix and twelve at night, and laſt till ſix, eight, or ten, in 'the morning. Dampier's Diſcourſe of Winds, chap. 4.

[b] One thing more I believe ſome of my friends will expect from me is, that I ſhew the reſult of comparing my own obſervations of the winds, with others they know I have from Ireland, Switzerland, Italy, France, New-England, and ſome of our parts in England. But the obſervations being, ſome of them, but of one year, and moſt of the reſt of but a few years, I have not been able to determine any great matters. The chief of what I have obſerved is, that the winds in all theſe places ſeldom agree; but when they moſt certainly

fore the winds, I proceed, in the next place, to clouds and rain.

certainly do ſo, it is commonly when the winds are ſtrong, and of long continuance in the ſame quarter: and more, I think, in the northerly and eaſterly, than other points. Alſo, a ſtrong wind in one place, is oftentimes a weak one in another place, or moderate, according as places have been nearer or farther diſtant. V. Phil. Tranſ. No 297, and 321. But to give a good and tolerable account of this, or any other of the weather, it is neceſſary to have good hiſtories thereof from all parts; which, as yet we have but few of, and they imperfect, for want of longer and ſufficient obſervations.

CHAP.

CHAP. III.

OF THE CLOUDS AND RAIN.

THE clouds and rain[c] we ſhall find to be no leſs uſeful meteors than the laſt mentioned; as is manifeſt in the refreſhing pleaſant ſhades which the

---

[c] Clouds and rain are made of vapours raiſed from water, or moiſture only. So that I utterly exclude the notion of dry, terrene exhalations, or fumes, talked much of by moſt philoſophers? fumes being really no other than the humid parts of bodies reſpectively dry.

Theſe vapours are demonſtratively no other than ſmall bubbles, or veſiculæ, detached from the waters by [the power of the ſolar, or ſubterraneous heat, or both. Of which, ſee book 2. chap. 5. And being lighter than the atmoſphere, are bouyed up thereby, until they become of an equal weight therewith, in ſome of its regions aloft in the air, or nearer the earth; in which thoſe vapours are formed into clouds, rain, ſnow, hail, lightning, dew, miſts, and others meteors.

In this formation of meteors the grand agent is cold, which commonly, if not always, occupies the ſuperior regions of the air; as is manifeſt from thoſe mountains which exalt their lofty tops into the upper and middle regions, and are always covered with ſnow and ice.

This

the clouds afford, and the fertile dews and ſhowers which they pour down on the trees and plants, which would languiſh and die with perpetual drought, but are

---

This cold if it approaches near the earth, preſently precipitates the vapours, either in dews; or if the vapours more copiouſly aſcend and ſoon meet the cold, they are then condenſed into miſling, or elſe into ſhowers of ſmall rain, falling in numerous, thick, ſmall drops; but if thoſe vapours are not only copious, but alſo as heavy as our lower air itſelf (by means their bladders are thick and fuller of water) in this caſe they become viſible, ſwim but a little height above the earth, and make what we call a miſt or fog. But if they are a degree lighter, ſo as to mount higher, but not any great height, as alſo meet not with cold enough to condenſe them, nor wind to diſſipate them, they then form an heavy, thick, dark ſky, laſting oftentimes for ſeveral weeks without either ſun or rain. And in this caſe, I have ſcarce ever known it to rain, till it hath been firſt fair, and then foul. And Mr. Clarke, an ingenious clergyman of Norfolk, who in his life-time, long before me, took notice of it, and kept a regiſter of the weather for thirty years, which his learned grandſon, Dr. Samuel Clarke, put into my hands, he (I ſay) ſaith, he ſcarce ever obſerved the rule to fail in all that time; only he adds, 'If the wind be in ſome of the 'eaſterly points.' But I have obſerved the ſame to happen, be the wind where it will. And from what hath been ſaid, the caſe is eaſily accounted for, viz. whilſt the vapours remain in the ſame ſtate, the weather doth ſo too. And ſuch weather is generally attended with moderate warmth, and with little or no wind to diſturb the vapours, and an heavy atmoſphere to ſupport them, the barometer being commonly high then. But when the cold approacheth, and by condenſing drives the vapours into clouds or drops, then is way made for the ſun beams, till the ſame vapours, being by further condenſation formed into rain, fall down in drops.

The cold's approaching the vapours, and conſequently the alteration of ſuch dark weather, I have before-hand perceived, by ſome few are hereby made verdant and flouriſhing, gay and ornamental! So that (as the pſalmiſt ſaith, Pſalm lxv.

few ſmall drops of rain, hail, or ſnow, now and then falling before any alteration hath been in the weather; which I take to be from the cold meeting ſome of the ſtraggling vapours, or the uppermoſt of them, and condenſing them into drops, before it arrives unto, and exerts itſelf upon the main body of vapours below.

I HAVE more largely than ordinary inſiſted upon this part of the weather, partly as being ſomewhat out of the way; but chiefly becauſe, it gives light to many other phaenomena of the weather. Particularly we may hence diſcover the original of clouds, rain, hail, and ſnow; that they are vapours carried a-loft by the gravity of the air, which meeting together, ſo as to make a fog above, they thereby form a cloud. If the cold condenſeth them into drops, they then fall in rain, if the cold be not intenſe enough to freeze them: but if the cold freezeth them in the clouds, or in their fall through the air, they then become hail or ſnow.

As to lightning, and other enkindled vapours; I need ſay little in this place, and ſhall therefore, only obſerve, that they owe alſo their riſe to vapours; but ſuch vapours as are detached from mineral juices, or at leaſt that are mingled with them, and are fired by fermentation.

ANOTHER phaenomenon reſolvable from what has been ſaid is, why a-cold is always a wet ſummer, viz. becauſe the vapours riſing plentifully then, are by the cold, ſoon collected into rain. A remarkable inſtance of this, we had in the ſummer of 1708, part of which, eſpecially about the ſolſtice, was much colder than uſually. On June 12, it was ſo cold, that my thermometer was near the point of hoar froſt; and in ſome places I heard there was an hoar froſt; and during all the cool weather of that month, we lxv. 12, 13.) *The little hills rejoice on every ſide, and the valleys ſhout for joy, they alſo ſing.*

AND

we had frequent and large rains, ſo that the whole month's rain amounted to above two inches depth, which is a large quantity for Upminſter, even in the wetteſt months. And not only with us at Upminſter, but in other places, particularly at Zurich in Switzerland, they ſeem to have had as unſeaſonable cold and wet as we. 'Fuit hic menſis—præter modum humidus, et magno quidem 'vegetalibibus hominibuſque damno. Multum computruit foenum,' &c. complains the induſtrious and learned D. J. J. Scheuchzer: of which and other particulars I have given a large account, in Phil. Tranſ. No. 321.

IN which tranſaction I have obſerved further, that about the equinoxes, we, at Upminſter at leaſt, have oftentimes more rain than at other ſeaſons. The reaſon of which is manifeſt from what hath been ſaid, viz. in ſpring, when the earth and waters are looſed from the brumal conſtipations, the vapours ariſe in great plenty: and the like they do in autumn, when the ſummer heats, that both diſſipated them, and warmed the ſuperior regions, are abated; and then the cold of the ſuperior regions meeting them, condeſcendeth them into ſhowers, more plentifully than at other ſeaſons, when either the vapours are fewer, or the cold that is to condenſe them is leſs.

THE manner how vapours are precipitated by the cold, or reduced into drops, I conceive to be thus: vapours being, as I ſaid, no other than inflated veſiculæ of water, when they meet with a colder air, than what is contained in them, the contained air is reduced into a leſs ſpace, and the watery ſhell or caſe rendered thicker by that means, ſo as to become heavier than the air, by which they are buoyed up, and conſequently muſt needs fall down. Alſo many of thoſe thickened veſiculæ, run into one, and ſo form drops, greater or ſmaller, according to the quantity of vapours collected together.

As

And if to theſe uſes, we ſhould add the origine of fountains, and rivers to vapours and the

rains,

As to the rain of different places, I have in ſome of our tranſactions aſſigned the quantities; particularly in the laſt cited tranſaction, I have aſſigned theſe, viz. the depth of the rain one year with another, in Engliſh meaſure, if it was to ſtagnate on the earth, would amount unto, at Townley in Lancaſhire, 42 inches and a half; at Upminſter in Eſſex, 19 inches and a quarter; at Zurich in Switzerland, 32 inches and a quarter; at Piſa in Italy 43 inches and a quarter; at Paris in France 19 inches; and at Liſle in Flanders 24 inches.

It would be endleſs to reckon up the bloody and other prodigious rains taken notice of, by hiſtorians, and other authors, as praeternatural and ominous accidents; but if ſtrictly pried into, will be found owing to natural cauſes: of which, for the reader's ſatisfaction, I will give an inſtance or two. A bloody rain was imagined to have fallen in France, which put the country people into ſo great a fright, that they left their work in the fields, and in great haſte flew to the neighbouring houſes. Peireſk, then in the neighbourhood, ſtrictly inquiring into the cauſe, found it to be only red drops coming from a ſort of butterfly, that flew about in great numbers at that time, as he concluded from ſeeing ſuch red drops come from them; and becauſe theſe drops were laid. 'Non ſupra aedificia, non in devexis lapidum ſuperficiebus, uti deburet contingere, ſine coelo ſanguine pluiſſet; ſed in ſubcavis potius et in foraminibus—— acceſſit, quod parietes iis tingebantur, non quia in mediis oppidis, ſed qui agrorum vicina erant, neque ſecundum partes elatiores, ſed ad mediocrem ſolum altitudinem, quantem volitare papiliones ſolent.' Gaſſend. in vit. Peireſk, l. 2. p. 156.

So Dr. Merret ſaith alſo, 'Pluvia ſanguines quam certiſſime conſtat eſſe tantum inſectorum excrementa; pluvia tritici nihil alliud eſſe quam hederæ bacciferæ grana a ſturnis devorata

'excretaque

rains, as ſome of the moſt eminent modern philoſophers

excretaque comparanti liquidiſſime patet.' Pinax rerum, &c. p. 220.

THE curious Wormius tells of the raining of brimſtone, Ann. 1646. Maij 16. 'Hic Hafnia cum ingenti pluvia tota urbs, 'omneſque ita inunderantur plateæ, ut greſſus hominum im'pediret, ſulphureoque odore aerem inficeret, dilapſis, aliquantu'lum aquis, quibuſdam in locis colligere licuit ſulphuereum pul'verem, cujus portionem ſervo, colore, odore, et aliis verum ſul'pher ferentem. Muſ. Worm. l. 1. c. 11. ſect. 1.

TOGETHER with the rain we might take notice of other meteors, particularly ſnow; which although an irkſome gueſt, yet hath its great uſes, if all be true that the famous T. Bartholin ſaith of it, who wrote a book de Nevis Uſu Medico. In which he ſhows of what great uſe ſnow is, in fructifying the earth, preſerving from the plague, curing fevers, cholicks, head-aches, tooth-aches, ſore-eyes, pluriſies (for which uſe, he ſaith, his country-women of Denmark keep ſnow water, gathered in March) alſo in prolonging life (of which he inſtanceth in the Alpin inhabitants, that live to a great age) and preſerving dead bodies; inſtances of which he gives, in perſons buried under the ſnow in paſſing the Alps, which are found uncorrupted in the ſummer, when the ſnow is melted? which ſad ſpectacle he himſelf was an eye-witneſs of. And at Spitzſburgh in Greenland, dead bodies remain entire and uncorrupted for thirty years. And laſtly, concerning ſuch as are ſo preſerved when ſlain, he ſaith they remain in the ſame poſture, and figure; of which he gives this odd example. 'Viſum id extra urbem noſtram [Hafniam] quam 11, Feb. '1659, oppugnantes hoſtes repellerentur, magnaque ſtrage oc'cumberent; alii enim rigidi iratum vultum oſtendebant, alii o'culos elatos alii ore diducto ringentes, alii brachiis extenſis 'gladium minari, alii alio ſitu proſtrati jacebant.' Bar. de uſu niv. c. 12.

But although ſnow be attended with the effect here named and others ſpecified by the learned Bartholin; yet this is not to be attributed to any peculiar virtue in the ſnow, but ſome other cauſe. Thus when it is ſaid to fructify the earth, it doth ſo by guarding the corn or other vegetables againſt the intenſer cold of the air, eſpecially the cold piercing winds, which the huſbandmen obſerve to be the moſt injurious to their corn of all weathers. So for conſerving dead bodies, it doth ſo by conſtipating ſuch bodies, and preventing all ſuch fermentations, or internal conflicts of their particles, as would produce corruption.

Such an example as the preceding, is ſaid to have happened ſome years ago at Paris, in digging in a cellar for ſuppoſed hidden treaſure; in which, after digging ſome hours, the maid going to call her maſter, found them all in their digging poſtures, but dead. This being noiſed abroad, brought in not only the people, but magiſtrates alſo, who found them accordingly; 'Ille 'qui ligone terram effoderat, et ſocius qui palla effoſſam terram 'removerat, ambo pedibus ſtabant, quaſi ſuo quiſque operi affixus 'incubuiſſet; uxor unius quaſi ab opere defeſſa in ſcamno, ſolicito quodam vultu, ſedebat, inclinato in palmam manus geni'bus innitentis capite; puerulus laxatis braccis in margine exca'vatæ foveæ defixes in terram oculis alvum exonerabat; omnes 'in naturali ſitu carneæ tanquam ſtatuæ rigidi, apertis oculis et vultu vitam quaſi reſpirante, exanimes ſtabant.' Dr. Burn. Conner, Deſſert. Med. Phyſ. p. 15.

The doctor attributes all this to cold; but I ſcarce think there could be cold enough to do all this at Paris, and in a cellar too. But his following ſtories are not improbable, of men and cattle killed with cold, that remained in the very ſame poſture in which they died; of which he gives from a Spaniſh captain, this inſtance, that happened two years before, of a ſoldier, who unfortunately ſtraggled from his company, that were foraging, and was killed with the cold, but was thought to have fallen into the enemies hands. But ſoon after their return to their quarters they ſaw their comrade returning, ſitting on horſeback, and coming to congratulate him, found him dead, and that he had been brought phers [d] have done, we ſhould have another inſtance of the great uſe and benefit of that meteor.

And now, if we reflect upon this neceſſary appendage of the terraqueous globe, the atmoſphere, and conſider the abſolute neceſſity thereof to many uſes of our globe, and its great convenience to the whole; and in a word, that it anſwereth all the ends and purpoſes that we can ſuppoſe there can be for ſuch an appendage: who can but own this to be the contrivance, the work of the great Creator? Who would ever ſay or imagine ſuch a body, ſo different from the globe it ſerves, could be made by chance, or be adapted ſo exactly to all thoſe forementioned grand ends, by any other efficient than by the power and wiſdom of the infinite God! who would not rather, from ſo noble a

---

brought thither in the ſame poſture on horſeback, notwithſtanding the jolting of the horſe. Ib. p. 18.

[d] Of this opinion was my late moſt ingenious and learned friend Mr. Ray, whoſe reaſons ſee in his Phyſico-Theolog. Diſcourſes, Diſc. 2. ch 2. p. 89, &c. So my no leſs learned and ingenious friends, Dr. Halley, and the late Dr. Hook; and many of the French virtuoſos alſo, and divers other very conſiderable men before them, too many to be ſpecified here.

work, readily acknowledge the workman, [c] and as eaſily conclude the atmoſphere to be made by God, as an inſtrument wrought by its power, any pneumatic engine, to be contrived and made by man!

CHAP

---

[c] ‘ An Polycletum quidem admirabimur propter partium ſtatuæ —convenientiam ac proportionem; Naturam autem non modo non laudabimus, ſed omni etiam arte privabimus, quæ partium proportionem non ſolum extrinſecus more ſtatuariorum, ſed in profundo etiam ſervavit; Nonne et Polycletus ipſe naturæ eſt imitator, in quibus ſaltem eam potuit imitari? Potuit autem in ſolis externis partibus in quibus artem conſideravit.’ With much more to the like purpoſe. Galen de Uſ. Part. l. 17. c. 1.

CHAP. IV.

OF LIGHT.

THUS much for the firſt thing miniſtring to the terraqueous globe, the atmoſphere and its meteors; the next appendage is LIGHT.[f] Concerning which, I have in my ſurvey of the heavens[g] ſhewed what admirable contrivances the infinitely wiſe Creator hath for the affording this noble, glorious, and comfortable benefit to other globes, as well as ours; the proviſion he hath made by moons, as well as by the ſun, for the communication of it.

---

[f] IT is not worth while to enumerate the opinions of the Ariſtotelians, Carteſians, and others, about the nature of light; Ariſtotle making it a quality; Cartes a pulſion, or motion of the globules of the ſecond element Vide Cartes Prin. p. 3. ſect. 55. &c. But, with the moderns, I take light to conſiſt of material particles, propagated from the ſun, and other luminous bodies, not inſtanteouſly, but in time, according to the notes following in this chapter. But not to inſiſt upon other arguments for the proof of it, our nobl efounder hath proved the materiality of light and heat, from actual experiments on ſilver, copper, tin, lead, ſpelter, iron, tutenage and other bodies expoſed (both naked and cloſely ſhut up) to the fire: all which were conſtantly found to receive an increment of weight. I wiſh he could have met with a favourable ſeaſon to have tried his experiments with the ſun-beams as he intended Vide Boyle's Exp. to make fire and flame ponderable.

[g] Aſtro-Theol. book 7.

And now let us briefly conſider the great neceſſity and uſe thereof to all our animal world, And this we ſhall find to be little leſs than the very life and pleaſure of all thoſe creatures. For what benefit would life be of, what pleaſure, what comfort would it be for us to live in perpetual darkneſs? How could we provide ourſelves with food and neceſſaries? How could we go about the leaſt buſineſs, correſpond with one another, or be of any uſe in the world, or any creatures be the ſame to us, without light, and thoſe admirable organs of the body, which the great Creator hath adapted to the perception of that great benefit?

But now by the help of this admirable, this firſt-made [h], becauſe moſt neceſſary, creature of God; by this, I ſay, all the animal world is enabled to go here and there, as their occaſions call; they can tranſact their buſineſs by day, and refreſh and recruit themſelves by night, with reſt and ſleep. They can, with admiration and pleaſure, behold the glorious works of God; they can view the glories of the heavens, and ſee the beauties of the flowery fields, the gay attire of the feathered tribe, the exquiſite garniture of many quadrupeds, inſects and other creatures; they can take in the delightſome landſkips of divers countries and places; they can with admiration ſee the great Creator's wonderful art and contrivance in the parts of animals and vegetables: and, in a word, behold the harmony of this lower world, and of the globes above, and ſurvey God's exquiſite workmanſhip in every creature.

---

[h] 'And God ſaid, Let there be light, and there was light,' Gen. i. 3.

To all which I might add the improvements which the ſagacity of men hath made of this noble creature of God, by the refraction and reflection of glaſſes. But it would be endleſs to enumerate all its particular uſes and benefits to our world.

BUT before I leave this point, there are two things concerning light, which will deſerve an eſpecial remark; and that is, its ſwift and almoſt inſtantaneous motion, and its vaſt expanſion.

1. It is a very great act of the providence of God, that ſo great a benefit as light is, is not long in its paſſage from place to place. For, was the motion thereof no ſwifter than the motion of the ſwifteſt bodies on earth, ſuch as of a bullet out of a great gun; or even of a ſound[i], which is

---

[i] IT may not be ungrateful to the curious, to take notice of the velocity of thoſe two things.

ACCORDING to the obſervations of Merſennus, a bullet ſhot out the ſwifteſt motion we have next to light, in this caſe light would take up in its progreſs from the ſun to us, above thirty two years, at the rate of the firſt; and above ſeventeen years, at the rate of the latter motion.

The inconveniencies of which would be, its energy and vigour would be greatly cooled and abated; its rays would be leſs penetrant; and darkneſs would with greater difficulty and much ſluggiſhneſs, be diſſipated, eſpecially by the fainter lights of our ſublunary, luminous bodies. But paſſing with ſuch prodigious velocity, with nearly the inſtantaneous ſwiftneſs of almoſt two hundred thouſand Engliſh miles in one ſecond of time [k], or which is the ſame thing, being but

---

of a great gun, flies 92 fathom in a ſecond of time, (Vide Mer. Beliſt.) which is equal to 589 Engliſh feet and a half; and according to the computation of Mr. Huygens, it would be 25 years in paſſing from the earth to the ſun. But according to my own obſervations made with one of her late Majeſty's Sakers, and a very accurate pendulum-chronometer, a bullet at its firſt diſcharge, flies 510 yards in five half ſeconds, which is a mile in a little above 17 half ſeconds. And allowing the ſun's diſtance to be, as in the next note, a bullet would be 32 years and a half in flying, with its utmoſt velocity, to the ſun.

As to the velocity of ſounds, ſee book iv. chap. 3. according to which rate there mentioned, a ſound would be near 17 years and a half in flying as far as the diſtance is from the earth to the ſun. Confer here the experiments of the Acad. del Ciment. p. 140, &c.

[k] Mr. Romer's ingenious hypotheſis about the velocity of light, hath been eſtabliſhed by the Royal Academy, and in the Ob-

but about ſeven or eight minutes of an hour in coming from the ſun to us, therefore with all ſecurity and ſpeed, we receive the kindly effects and influences of that noble and uſeful creature of God.

2. ANOTHER thing of great conſideration about light is, its vaſt expanſion, its almoſt incomprehenſible, and inconceivable extenſion, which, as a late

---

Obſervatory, for eight years, as our Phil. Tranſ. No 136. obſerve from the Jour. des Scavans; our moſt eminent aſtronomers alſo in England admit it: but Dr. Hook thinks, with Monſieur Cartes, the motion of light inſtantaneous. Hook's Poſt. Works p. 77. And this he endeavours to explain, p. 130, &c.

WHAT Mr. Romer's hypotheſis is, may be ſeen in the Phil. Tranſ. before cited: and alſo in the before-mentioned Sir Iſaac Newton's Optics: 'Light is propagated from luminous bodies 'in time, and ſpends about ſeven or eight minutes of an hour 'in paſſing from the ſun to the earth. This was firſt obſerved by 'Romer, and then by others, by means of the eclipſes of the ſa'tellites of Jupiter. For theſe eclipſes, when the earth is between 'the Sun and Jupiter, happen about ſeven or eight minutes ſoon'er than they ought to do by the tables; and when the Earth is 'beyond the Sun, they happen about ſeven or eight minutes later 'than they ought to do: the reaſon being, that the light of the ſa'tellites hath farther to go in the latter caſe than in the former, 'by the diameter of the earths orbit.' New Op. l. 2. par. 3. pro. 11.

Now, for as much as the diſtance between the ſun and the earth (according to the computations in my Aſtro-The. b. i. c. 3. n. 2.) is 86,051,398 Engliſh miles; therefore, at the rate of 7 minutes and a half, or 459 ſeconds, in paſſing from the ſun, light will be found to fly above 191,225 miles in one ſecond of time.

ingenious author ſaith [l], ‘ Is as boundleſs and ‘ unlimited as the univerſe itſelf, or the expanſum ‘ of all material beings: the vaſtneſs of which is ſo ‘ great, that it exceeds the comprehenſion of man’s ‘ underſtanding. Inſomuch, that very many have ‘ aſſerted it abſolutely infinite, and without any limits or bounds.’

AND that this noble creature of God is of this extent [m] is manifeſt from our ſeeing ſome of the

fartheſt

---

[l] Dr. HOOK’s Poſthumous Works, Lect. of Light p. 76.

[m] FOR the proof of this vaſt extent of light, I ſhall take the computation of the ſame great man, p. 77. ‘ If, ſaith he, we ‘ conſider firſt, the vaſt diſtance between us and the ſun, which ‘ from the beſt and lateſt obſervations in aſtronomy, is judged ‘ to be about 10,800 diameters of the earth, each of which is ‘ about 7,925 Engliſh miles; therefore the ſun’s diſtance is ‘ 79,250,000 miles; and if we conſider, that, according to the ‘ obſervations, which I publiſhed to prove the motion of the ‘ earth,’ [which were obſervations of the parallax of ſome of the fixed ſtars in the head of Draco, made in 1699] ‘ the whole diameter of the orb, viz. 20,000, made the ſubtenſe of but one ‘ minute to one of the fix’d ſtars, which cannot therefore be leſs ‘ diſtant than 3,438 diameters of this great orb, and conſequently 68,760,000 diameters of the earth: and if this ſtar be one ‘ of the neareſt, and that the ſtars that are of one degree leſſer ‘ in magnitude (I mean not of the ſecond magnitude, becauſe ‘ there may be many degrees between the firſt and the ſecond) ‘ be as much farther; and another ſort yet ſmaller be three ‘ times as far; and a fourth four times as far, and ſo onward, ‘ poſſibly to ſome 100 degrees of magnitude, ſuch as may be ‘ diſcovered by longer and longer teleſcopes; that they may be 100 times as far; then certainly this material expanſion, a

‘ part

fartheſt diſtant objects, the heavenly bodies, ſome with our naked eye, ſome with the help of optical inſtruments, and others in all probability farther and farther, with better and better inſtruments: and had we inſtruments of power equivalent to the extent of light, the luminous bodies of the utmoſt parts of the univerſe, would, for the ſame reaſon, be viſible too.

Now, as light is of greateſt uſe to impower us to ſee objects at all, ſo the extenſion thereof is no leſs uſeful to enable us to ſee objects afar off. By which means we are afforded a ken of thoſe many glorious works of the infinite Creator, viſible in the heavens, and can improve them to ſome of the nobleſt ſciences, and moſt excellent uſes of our own globe.

'part of which we are, muſt be ſo great, that it will infinitely 'exceed our ſhallow conception to imagine. Now, by what I 'laſt mentioned, it is evident, that light extends itſelf to the 'utmoſt imaginable parts, and, by the help of teleſcopes, we 'collect the rays, and make them ſenſible to the eye, which 'are emitted from ſome of the almoſt inconceivable remote objects, &c.——Nor is it only the great body of the ſun, or the 'vaſt bodies of the fix'd ſtars, that are thus able to diſperſe the 'light through the vaſt expanſum of the univerſe; but the 'ſmalleſt ſpark of a lucid body muſt do the very ſame thing, 'even the ſmalleſt globule ſtruck from a ſteel by a flint,' &c.

CHAP. V.

OF GRAVITY.

THE laſt thing ſubſervient to our globe, that I ſhall take notice of, is GRAVITY[n]; or, that tendency which bodies have to the centre of the earth.

In

---

[n] THAT there is ſuch a thing as Gravity, is manifeſt from its effects here upon earth; and that the heavenly bodies attract or gravitate to one another, when placed at due diſtances, is made highly probable by Sir Iſaac Newton. This attractive, or gravitating power, I take to be congenial to matter, and imprinted on all the matter of the univerſe by the Creator's Fiat at the creation. What the cauſe of it is, the Newtonian philoſophy doth not pretend to determine for want of phænomena, upon which foundation it is that that philoſophy is grounded, and not upon chimerical and uncertain hypotheſes: but whatever the cauſe is, that 'cauſe penetrates even to the centres of the ſun and planets, 'without any diminution of its virtue; and it acteth not according to the ſuperficies of bodies, as mecharical cauſes do; but in 'proportion to the quantity of their ſolid matter: and laſtly, it 'acteth all round it at immenſe diſtances, decreaſing in duplicate 'proportion to thoſe diſtances,' as Sir Iſaac Newton ſaith, Princip. p. ult. What uſeful deductions, and what a rational philoſophy, have been drawn from hence, may be ſeen in the ſame book

THIS attraction, or gravity, as its force is in a certain proportion, ſo makes the deſcent of bodies to be at a certain rate. And

In my Aſtro-Theology, book vi. chap. 2. I have ſhewn of what abſolute neceſſity, and what a noble contrivance this of gravity is, for keeping the ſeveral globes of the univerſe from ſhattering to pieces as they evidently muſt do in a little time, by their ſwift

And was it not for the reſiſtance of the medium, all bodies would deſcend to the earth at the ſame rate; the lighteſt down, as ſwiftly as the heavieſt mineral: as is manifeſt in the air-pump, in which the lighteſt feather, duſt, &c. and a piece of lead, drop down ſeemingly in the ſame time, from the top to the bottom of a tall exhauſted receiver.

The rate of the deſcent of heavy bodies, according to Galilæo, Mr. Huygens, and Dr. Halley after them, is 16 feet one inch in one ſecond of time; and in more ſeconds, as the ſquares of thoſe times. But in ſome accurate experiments made in St, Paul's dome, June 9, 1710, at the height of 220 feet, the deſcent was ſcarcely 14 feet in the firſt ſecond. The experiments were made in the preſence of ſome very conſiderable members of the royal ſociety, by Mr. Hawkſbee, their operator, with glaſs, hollow balls, ſome empty, ſome filled with quick-ſilver, the barometer at 297, the thermometer 60 degrees about freezing. The weight of the balls, their diameters, and time of their deſcent is in this table.

Balls fill'd with quick-ſilver.			Empty balls.		
Weight.	Diameter.	Time.	Weight.	Diameter.	Time.
Grains.	Ten. Inch.	half Second.	Grains.	Inch. Tent	half Second
908	8	8	510	5 1	17
993	8	8 leſs.	642	5 2	16
866	8	8	599	5 1	
747	7 & half.	8 more.	515	5 nearly	16 & half.
808	7 & half.	8	483	5 nearly	17
784	7 & half.	8 more.	641		1

ſwift rotation round their own axes [o]. The terraqueous globe particularly, which circumvolves at

---

The reaſon why the heavy full balls fell in half the time of the hollow ones, was the reſiſtance of the air: which reſiſtance is very ingeniouſly and accurately aſſigned by Dr. Wallis, in Phil. Tranſ. No. 186. And the cauſe of reſiſtance of the fluids (as Sir Iſaac Newton, Opt. Q. 20.) is partly from the friction of the parts of the fluid, partly from the inertia thereof. The reſiſtance a ſpherical body meets with from friction, is as the right angle under the diameter, and the velocity of the moving body; and the reſiſtance from the vis inertiæ, is as the ſquare of that product.

For a further account of the properties and proportions &c. of gravity, in the fall or projection of bodies, I ſhall refer to the larger accounts of Galilæus, Torricellius, Huygens, Sir Iſaac Newton &c. or to to the ſhorter accounts of Dr. Halley, in Philoſ. Tranſ. abridged by Mr. Lowthorp, vol. 1, p. 561, or Dr. Clarke, in his notes on Rohault, Phyſ. 2,c. 28, ſect. 13, 16. And for the reſiſtance of fluids, I refer to Dr. Wallis, before cited, and the Act. Erudit. Lipſ. May 1693, where there is a way to find the force of mediums upon bodies of different figures.

[o] That the heavenly bodies move round their own axes, is beyond all doubt, manifeſt to our eye, in ſome of them, from the ſpots viſible on them. The ſpots on the ſun, eaſily viſible with an ordinary glaſs, do manifeſt him to revolve round his own axis in about 25 days and a quarter. The ſpots on Jupiter and Mars prove thoſe two planets, to revolve alſo from the eaſt to weſt, as Dr. Hook diſcovered in 1664, and 1665. And Venus alſo, although near the ſtrong rays of the ſun, hath from ſome ſpots, been, diſcovered by Mr. Caſſini, in 1666, and 1667, to have a manifeſt rotation. Vide Lowth. Abridg. vol. I. p. 382, and 423, 425. And ſuch uniformity hath the creator obſerved in the works of nature, that what is obſervable in one, is generally to be found in all others of the ſame kind. So that ſince it is manifeſt the ſun, and three

at the rate of above 1000 miles an hour [p], would by the centrifugal force of that motion, be ſoon diſſipated and ſpirtled into the circumambient ſpace, was it not kept together by this noble contrivance of the Creator, this natural inherent power, namely, the power of attraction or gravity.

AND as by this power our globe is defended againſt diſſipation; ſo all its parts are kept in their proper place and order. All material things do naturally gravitate thereto, and unite themſelves therewith, and ſo preſerve its bulk entire [r]. And the fleeting waters, the moſt unruly of all its parts,

---

three of his planets whirl round, it is very reaſonable to conclude all the reſt do ſo too; yea, every globe of the univerſe.

[p] THE earth's circumference being 25,031 miles and a half, (according to book II. chap. 2, If we divide that into 24 hours, we ſhall find the motion of the earth to be near, 1043 miles in an hour. Which, by the bye, is a far more reaſonable and leſs rapid rate, than that of the ſun would be, if we ſupppoſe the earth to ſtand ſtill, and the ſun to move round the earth. For according to the proportions in note [k] p. 38, of the preceding chapter, the circumference of the Magnus Orbis is 540,686,225 Engliſh miles, which divided by 24 hours, gives 22,528,364 miles in an hour. But what is this to the rapidity of the fix'd ſtars, if we ſuppoſe them, not the earth, to move? which is a good argument for the earth's motion.

[r] Nihil majus, quam quod ita ſtabilis eſt mundus, atque ' ita cohæret ad permanendum, ut nihil ne excogitari quidem poſ- ' ſit aptius. Omnes enim partes ejus undique medium locum ca- ' peſſentes

parts, do by this means keep their conſtant equipoiſe in the globe [r], and remain in that place which, the pſalmiſt ſaith, 'God hath founded for 'them; a bound he had ſet, which they might 'not paſs; that they turn not again to cover the 'earth,' Pſal. civ. 8, 9. So that even in a natural way, by virtue of this excellent contrivance of the Creator, the obſervation of the pſalmiſt is perpetually fulfilled, Pſal. lxxxix. 9. 'Thou 'ruleſt the raging of the ſea, when the waves there'of ariſe thou ſtilleſt them.'

To theſe, and an hundred other uſes of gravity, that I might have named, I ſhall only juſt mention another thing, owing to it, and that is *levity*, [s] that whereby, what we call light bodies ſwim, a thing no leſs uſeful to the world than its oppoſite gravity

---

poſſentes, nituntur , equaliter: maxime autem corpora inter ſe 'juncta permanent, cum quodam quaſi vinculo circumdata colligantur; quod facit ea natura, quæ per omnem mundum, omnia mente et ratione conficiens, funditer, et ad medium rapit, et 'convertit extrema.' Cic. de Nat. Deor. l, ii. c. 45.

[r] 'EADEM ratione mare, cum ſupra terram ſit, medium tamen 'terræ locum expetens, conglobatur undique æqualiter, neque re'dundat unquam, neque effunditur.' Id paulo poſt.

[s] THERE is no ſuch thing as poſſitive levity, but that levity, is only a leſs gravity, is abundantly manifeſted by the acute Seign. Alph. Borrelli de Mot. a grav. pend. cap. 4. See alſo the annotations of the learned and ingenious Dr. Clarke on Rohaulti

gravity, is, in many reſpects to divers tribes of animals but particularly ſerviceable to the raiſing up of vapours [t] and to their conveyance about the world.

And now from this tranſient view of no other than the out-works, than the bare appendages of the terraqueous globe, we have ſo manifeſt a ſample of the wiſdom power and goodneſs of the infinite Creator, that it is eaſy to imagine the whole fabric is of a piece, the work at leaſt of a ſkillful artiſt. A man

---

Rohaulti Phyſ. p. 1. c. 16. Note 3. Alſo the experiments of the Acad. del Cimento, p. 118, &c. Dr. Wallis's Diſcourſe of Gravity, and Gravitation before the Royal Society Nov. 12. 1674. p. 28 &c.

[t] I have before in note [c], chap. 3, page 26, ſhewn what vapours are, and how they are raiſed. That which I ſhall here note, is their quantity: concerning which, the before-commended Dr. Halley hath given us ſome curious experiments in our Philoſ. Tranſact. which may be met with together in Mr. Lowthorp's Abridg. vol. II, 108, and p.126. Mr. Sedileau alſo at Paris. obſerved it for near three years. By all their obſervations it appears, that in the winter months the evaporations are leaſt, and greateſt in ſummer, and moſt of all, in windy weather. And by Monſ. Sedileau's obſervations it appears, that what is raiſed in vapours exceeds that which falleth in rain. In the ſeven laſt months of the year, 1688, the evaporations amounted to 22 inches 5 lines; but the rain only 10 inches 6 lines one third: in 1689, the evaporations, were 32 inches 10 lines, and a half; but the rain 18 inches, one line; in 1690, the evaporatious 32 inches 11 lines

man that ſhould meet with a palace [u] beſet with pleaſant gardens, adorned with ſtately avenues, furniſhed with well contrived aqueducts, caſcades, and all other appendages conducing to convenience or pleaſure, would eaſily imagine, that proportionable architecture and magnificence were within; but we ſhould conclude the man was out of his wits that ſhould aſſert and plead that all was the work of chance, or other than of ſome wiſe and ſkilful hand. And ſo when we ſurvey the bare out-works of this our globe, when we ſee ſo vaſt a body accoutred with ſo noble a furniture of air, light and gravity; with every thing in ſhort, that is neceſſary to the preſervation and ſecurity of the globe itſelf, or that conduceth to the life, health, and happineſs to the propagation and increaſe of all the prodigious

---

11 lines; the rain 21 inches, one third of a line. Vide Memb. de Math. Phyſ. An. 1692, p. 25.

If it be demanded, what becomes of the overplus of exhalations that deſcend not in rain? I anſwer, they are partly tumbled down, and ſpent by the winds, and partly deſcend in dews, which amount to a greater quantity than is commonly imagined. Dr. Halley found the deſcent of vapours in dews, ſo prodigious at St. Helena, that he makes no doubt to attribute the origin of fountains thereto. And I myſelf, have ſeen in a ſtill, cool evening, large thick clouds hanging, without any motion, in the air, which in two or three hours time, have been melted down by degrees, by the cold of the evening, ſo that not any the leaſt remains of them have been left.

[u] See book ii. chap. 3.

ous variety of creatures the globe is ſtocked with; when we ſee nothing wanting, nothing redundant or frivolous, nothing botching or ill made, but that every thing, even in the very appendages alone, exactly anſwereth all its ends and occaſions: what elſe can be concluded, but that all was made with manifeſt deſign, and that all the whole ſtructure is the work of ſome intelligent being; ſome artiſt of power and ſkill, equivalent to ſuch a work.

BOOK II.

OF THE TERRAQUEOUS GLOBE ITSELF IN GENERAL.

IN the foregoing book having diſpatched the outworks, let us take a ſurvey of the principal fabric, viz. the terraqueous globe itſelf; a moſt ſtupendous work in every particular of it, which doth no leſs aggrandize its maker [u] than every curious, complete work doth its workman. Let us caſt our eyes here and there, let us ranſack all the globe, let us with the greateſt accuracy inſpect every part thereof, ſearch out the inmoſt ſecrets of any of the creatures; let us examine them with all our gauges, meaſure them with our niceſt rules, pry into them with our microſcopes, and moſt exquiſite inſtruments [y] ſtill we find them to bear teſtimony to their infinite workman; and that they exceed all human ſkill ſo far, as that the moſt exquiſite copies and imitations of the beſt artiſts are no other than rude bungling pieces to them. And ſo far are we from being able to eſpy any defect or fault in them, that the better we know them, the more we admire them; and the farther we ſee into them, the more exquiſite we find them to be. And for a demonſtration of this I ſhall:

---

[u] LICET oculis, quodammodo contemplari pulchritudinem earum rerum, quas divina providentia dicimus conſtitutas. Ac principio terra univerſa cernatur, locata in media mundi ſede, ſolida, et globoſa—veſtita floribus, herbis, arboribus, frugibus. Quorum omnium incredibilis multitudo, inſatiabili varietate diſtinguitur. Adde huc fontium gelidas perennitates, liquores perlucidos amnium, riparum veſtitus viridiſſimos, ſpeluncarum concavas altitudines, ſaxorum aſperitates, impendentium montium altitudines, immenſitateſque camporum: adde etiam reconditas auri venas—quae vero, et quam varia genera beſtiarum?——qui volucrum lapſus. atque cantus? Qui pecudum paſtus?——quid de hominum genere dicam? Qui quaſi cultores terrae conſtituti, &c.——quae ſi, ut animis, ſic oculis videre poſſemus, nemo

I. Take a general proſpect of the terraqueous globe.

II. Survey its particulars.

I. The things which ſhall fall under a general proſpect of the globe, will be its figure, bulk, mo-

---

' nemo cunctam intuens terram, de divina ratione dubitaret.' Cic. de Nat. Deor. l. 2. c. 39.

[y] 'I cannot here omit the obſervations that have been 'made in theſe latter times, ſince we have had the uſe and im- 'provement of the microſcope, concerning the great difference 'which by the help of that, doth appear betwixt natural and ar- 'tificial things. Whatever is natural, doth by that appear adorn-

tion, place, diſtribution into the earth and waters, and the great variety of all things upon it and in it.

CHAP.

'ed with all imginable elegance and beauty.—Whereas the 'moſt curious works of art, the ſharpeſt fineſt needle, doth ap'pear as a blunt rough bar of iron, coming from the furnace, or 'the forge. The moſt accurate engravings or emboſſments ſeem 'ſuch rude, bungling deformed works, as if they had been done 'with mattock or a trowel. So vaſt a difference is there betwixt 'the ſkill of nature, and the rudeneſs and imperfections of art.' Biſhop Wilk. Nat. Rel. l. 1, ch. 6.

CHAP.

CHAP. I.

OF THE FIGURE OF THE TERRAQUEOUS GLOBE.

THIS I ſuppoſe I may take for granted to be ſpherical, or nearly ſo [*]. And this muſt be allowed to be the moſt commodious, apt figure for

---

[*] ALTHOUGH the terraqueous globe be of an orbicular figure, yet it is not ſtrictly ſo. 1. On account of its hills and vallies. But theſe are inconſiderable to the earth's ſemidiameter; for they are but as the duſt upon a common globe. But, 2. Our modern Aſtronomers, aſſign a much greater variation from a globous form, namely that of a prolate ſpheroid, making the polar about 34 miles ſhorter than the equatorial diameter. The cauſe of which they make to be the centrifugal force of the diurnal rotation of the globe.

THIS figure they imagine is in Jupiter, his polar being to his equatorial diameter, as 39 three fifths to 40 three fifths. But whether it be ſo or no, I confeſs I could never perceive, although I have often viewed that planet through very good and long glaſſes, particularly a tolerable good one, of 72 feet in my hands: and although by reaſon of cloudy weather, and at preſent Jupiter's proximity to the ſun, I have not been of late able to take a review of that planet; yet Saturn, ſo far as his ring would permit, and Mars appear perfectly round, through Mr. Huygens's long glaſs, of 126 feet, which by will, he bequeathed, with its whole apparatus, to our Royal Society, by whoſe favour it is now in my hands, and moreover, I believe it difficult next to impoſſible to meaſure the two Diameters, to a fortieth part by reaſon for a world on many accounts; as it is moſt capacious, as its ſurface is equi-diſtant from the center, not only of the globe, but at leaſt (nearly) of gravity and motion too, and, as ſome have thought,

reaſon of the ſmallneſs of Jupiter's apparent diameter, and by reaſon he is moving all the time of meaſuring him.

As to what is alledged from lengthening the pendulums of clocks, to make them keep the ſame time under the equator, as they do in our climes; I have ſhewn, from the like variations in the air-pump, that this may ariſe from the rarity of the air there, more than here. Vide Phil. Tranſ. N° 294. But if the degrees of a meridian grow larger, the more we go towards the line (as Mr. Caſſini affirms they do, by an 800th part in every degree, in Phil. Tranſ. N° 278.) then there is great reaſon to conclude in behalf of this ſpheroidal form.

The natural cauſe of this ſphericity of our globe, is (according to Sir Iſaac Newton's principles) that attraction, which the infinite Creator hath ſtamped on all the matter of the univerſe, whereby all bodies, and all the parts of bodies, mutually attract themſelves, and one another. By which means, as all the parts of bodies tend naturally to their center, ſo they all betake themſelves to a globous figure unleſs ſome other more prevalent cauſe interpoſe. Thus, drops of quick-ſilver put on a ſpherical form the parts thereof ſtrongly attracting one another. So drops of water have the ſame form, when falling in the air: but are hemiſpherical only when they lie on a hard body, by reaſon their gravity doth ſo far over-power their ſelf-attracting power, as to take off one half of their ſphericity. This figure is commonly attributed to the preſſure of the circumambient air: but that this cannot be the cauſe, is manifeſt from the air-pump; the caſe being the very ſame in an exhauſted receiver, as in the open air, and not any the leaſt alteration of the figure that I could perceive, in all the trials I have made.

TI

thought, of the central heat and waters. But theſe, and divers other things, I ſhall paſs over, and inſiſt only upon two or three other benefits of this globous figure of the earth and waters.

1. This figure is the moſt commodious in regard of heat, and, I may add, of light alſo in ſome meaſure, For, by this means, thoſe two great benefits are uniformly and equally imparted to the world: they come harmoniouſly and gradually on, and as gradually go off again. So that the daily and yearly returns of light and darkneſs, cold and heat, moiſt and dry, are regular and workman-like, we may ſay, which they would not be, eſpecially the former, if the maſs of earth and waters were, as ſome fancied it [x],

---

[x] It would be frivolous, as well as endleſs, to reckon up the various opinions of the antients about the figure of the terraqueous globe; ſome of them way be ſeen in Varen. Geogr. l. 1. c. 3 init. or Johnſton's Thaumat. c 1. artic. 3. But among the variety of opinions, one of the principal was, that the viſible horizon, was the bounds of the earth, and the ocean th bounds of the horizon, that the heavens and earth above this ocean, was the whole viſible univerſe; and that all beneath the ocean was Hades, or the inviſible world. Hence, when the ſun ſet, he was ſaid ‘ tingere ſe oceano;’ and when any went to Hades, they muſt firſt paſs the ocean. Of this opinion were not only the antient poets, and others among the heathens, but ſome of the chriſtian fathers too, particularly Lactantius, St. Auguſtine, and others, who thought their opinion was favoured by the pſalmiſt, in Pſalm xxiv, 2. and cxxxvi. 6. See biſhop Uſher's anſwer to a Jeſ. Chall. p. 366, &c.

a large plain; or, as others, like a large hill in the midſt of the ocean; or of a multangular figure; or ſuch like.

2 THIS figure is admirably adapted to the commodious and equal diſtribution of the waters in the globe. For ſince by the laws of gravity, the waters will poſſeſs the loweſt place; therefore, if the maſs of the earth was cubic, priſmatic, or any other angular figure, it would follow, that one, too vaſt a part would be drowned; and another be too dry. But being thus orbicular, the waters are equally and commodiouſly diſtributed here and there, according as the divine providence ſaw moſt fit; of which I ſhall take notice by and by.

3. THE orbicular figure of our globe is far the moſt beneficial to the winds and motions of the atmoſphere. It is not to be doubted, if the earth was of ſome other, or indeed any other figure, but that, the currents of air would be much retarded, if not wholly ſtopped. We find by experience, what influence large and high mountains, bays, capes, and head-lands, have upon the winds; how they ſtop ſome, retard many, and divert and change, near the ſhores, even the general and conſtant, winds [y], that blow round

---

[y] 'Neither do theſe conſtant trade-winds uſually blow near 'the ſhore, but only on the ocean, at leaſt 30 or 40 leaguues off 'at

the globe in the torrid zone. And theref ſince this is the effect of ſuch little excreſcen which have but little proportion to our gl what would be the conſequences of much va angles, which would equal a quarter, tenth, but an hundredth part of the globe's radi Certainly theſe muſt be ſuch a barricade, as wo greatly annoy, or rather abſolutely ſtop, currents of the atmoſphere, and thereby dep the world of thoſe ſalutiferous gales that I have keep it ſweet and clean.

Thus the figure of our globe both man it to be a work of contrivance, in as muc it is of the moſt commodious figure; and others would be liable to great and evident in veniences.

' at ſea, clear from any land; eſpecially on the weſt coa ' ſide of any continent: for indeed on the eaſt ſide, the e ' ly wind being the true trade-wind blows almoſt home t ' ſhore, ſo near as to receive a check from the land w Dampier's Winds, ch. 1.

And not only the general trade-winds, but alſo the co coaſting trade-winds, are, in like manner, affected by the l Thus, for inſtance, on the coaſt of Angola and Peru. Bu ſaith the curious captain Dampier, the reader muſt take noti ' That the trade-winds that blow on any coaſt, except the ' coaſt of Africa, whether they are conſtant, and blow al ' year, or whether they are ſhifting winds, do never blow ' in on the ſhore, nor right along ſhore, but go ſlanting, m ' an acute angle of about 22 degrees. Therefore, as the ' tends more eaſt or weſt, from north or ſouth on the coa ' the winds do alter accordingly.' Ibid. ch. 2.

C

CHAP. II

OF THE BULK OF THE TERRAQUEOUS GLOBE.

THE next thing remarkable in the terraqueous globe, is the prodigious bulk thereof[z]. A maſs of above 260 thouſand millions of miles ſolid content. A work too grand for any thing leſs than a God to make. To which, in the next place, we may add,

---

[z] IT is not difficult to make a pretty near computation of the bulk of the terraqueous globe, from thoſe accurate obſervations of a degree made by Mr. Norwood in England, and Mr. Picart, and Mr. Caſſini in France, whoſe meaſures do in a ſurprizing manner agree. But Mr. Caſſini's ſeeming to be the moſt accurate, (as I have ſhewn in my Aſtro-Theology, book 1. chap. 2.) I have therefore made uſe of his determination. According to which, the diameter of the earth being 7967·7 Engliſh miles, its ambit will be 25,031 miles and half; and, ſuppoſing it to be ſpherical, its ſurface will be 199,444,220, miles; which being multiplied into one third of its ſemidiameter, gives the ſolid content, viz. 264,856,000,000 miles.

CHAP. III.

THE MOTIONS OF THE TERRAQUEOUS GLOBE.

THE motions the terraqueous globe hath are round its own axis, and round its fountain of light and heat, the ſun[a]. That ſo vaſt a body as the earth and waters ſhould be moved at all[b], that it ſhould undergo two ſuch different motions, as

---

[a] With the Copernicans, I take it here for granted, that the diurnal and annual revolutions are the motions of the terraqueous globe, not of the ſun, &c. but for the proof thereof I ſhall refer the reader to the preface of my Aſtro-Theology, and book iv. chap. 3.

[b] 'Every thing that is moved, muſt of neceſſity be moved by 'ſomething elſe; and that thing is moved by ſomething that is 'moved either by another thing, or not by another thing. If it be 'moved by that which is moved by another, we muſt of neceſſity 'come to ſome prime mover, that is not moved by another. For it 'is impoſſible, that what moveth, and is moved by another, ſhould 'proceed in infinitum.' Ariſt. Phyc. l. 8. c. 5.

'Solum quod ſeipſum movet, quod nunquam deſeritur a ſe, 'nunquam ne moveri quidem deſinit: quin etiam cæteris quæ mo-'ventur, hic fons, hoc principium eſt movendi. Principii autem 'nulla eſt origo: nam ex principio oriuntur omnia; ipſum autem 'nulla

as the diurnal and annual are, and that theſe motions ſhould be ſo conſtantly and regularly [c] performed for near 6000 years, without any the leaſt alteration ever heard of, (except ſome hours which we read of in Joſh. x. 12, 13. and in Hezekiah's time, which, if they cannot be accounted for ſome other way, do greatly increaſe the wonder [d]; theſe

---

' nulla ex re alia naſci poteſt: nec enim eſſet id principium, quod ' gigneretur aliunde.' Cic. Tuſc. Quaeſt. l. 1. c. 23.

' Cogitemus qui fieri poſſit, ut tanta magnitudo, ab aliqua poſſit ' natura, tanto tempore circumferri? Ego igitur aſſero Deum ' cauſam eſſe, nec aliter poſſe fieri.' Plato in Epinom.

[c] Among the cauſes which Cleanthes is ſaid in Tully to aſſign for man's belief of a Deity, one of the chief is. ' Aequabilitatem ' motus, converſionem coeli, ſolis, lunae, ſiderumque omnium ' diſtinctionem, varietatem, pulchritudinem, ordinem: quarum ' rerum aſpectus ipſe ſatis indicaret, non eſſe ea fortuita. Ut ' ſiquis in domum aliquam aut in gymnaſium, aut in forum ' venerit; cum videat omnium rerum rationem, modum, ' diſciplinam, non poſſit ea ſine cauſa fieri judicare, ſed eſſe aliquem ' intelligat, qui praeſit, et cui pareatur: multo magis id tantis mo' tibus, tantiſque viciſſitudinibus, tam multarum rerum atque tan' tarum ordinibus, in quibus nihil unquam immenſa et infinita ' vetuſtas mentita ſit, ſtatuat neceſſe eſt ab aliqua mente tantos ' naturae motus gubernari.' Cic. de Nat. Deor. l. 2. c. 5.

' Homines coeperunt Deum agnoſcere, cum viderent ſtellas, tan' tam concinnitatem efficere; ac dies, noctesque aeſtate, et hyeme, ' ſuos ſervare ſtatos ortus, atque obitus' Plut. de plac. l. 1. c. 6.

[d] We need not be ſolicitous to elude the hiſtory of theſe miracles, as if they were only poetical ſtrains, as Maimonides and

theſe things, I ſay,) do manifeſtly argue ſome divine infinite power to be concerned therein [e]: but, eſpecaally, if to all this we add the wonderful convenience, yea, abſolute neceſſity of theſe circumvolutions to the inhabitants, yea, all the products of the earth and waters. For to one of theſe we owe the comfortable changes of day and night; the

---

and ſome others, fancy Joſhua's day to have been, viz. only an ordinary ſummer's day; but ſuch as had the work of many days done in it; and therefore, by a poetical ſtretch made, as if the day had been lengthened by the ſun ſtanding ſtill. But in the hiſtory they are ſeriouſly related, as real matters of fact, and with ſuch circumſtances as manifeſt them to have been miraculous works of the Almighty: and the prophet Habakkuk, iii. 11. mentions that of Joſhua as ſuch. And therefore, taking them to be miraculous perverſions of the courſe of nature, inſtead of being objections, they are great arguments of the power of God: for, in Hezekiah's caſe, to wheel the earth itſelf backward, or by ſome extraordinary refractions to bring the ſun's ſhadow backwards 10 degrees: or in Joſhua's caſe, to ſtop the diurnal courſe of the globe for ſome hours, and then again give it the ſame motion; to do, I ſay, theſe things, required the ſame infinite power which at firſt gave the terraqueous globe its motion.

[e] Nam cum diſpoſiti quaeſiſſem foedera mundi,
Praeſcriptosque maris fines, annique meatus,
Et lucis, noctiſque vices: tunc omnia rebar
Conſilio firmata Dei, qui lege moveri
Sidera, qui fruges diverſo tempore naſci,
Qui variam Phoeben alieno juſſerit igne
Compleri, ſolemque ſuo; porrexerit undis
Littora; tellurem medio libraverat axe,
Claudian in Rufin. L. 1. initio.

one for buſineſs, the other for repoſe [f]: the one for man, and moſt other animals to gather and provide food, habitation, and other neceſſaries of life; the other to reſt, refreſh, and recruit their ſpirits [g], waſted with the labours of the day. To the other of thoſe motions we owe the ſeaſons of ſummer and winter, ſpring and autumn, together with the beneficial influences and effects which theſe have on the bodies and ſtate of animals, vegetables, and all other things, both in the torrid, temperate, and frigid zones.

---

[f] ‘ Diei noctiſque viciſſitudo conſervat animantes, tribuens
‘ aliud agendi tempus, aliud quieſcendi. Sic undique omni ratione
‘ concluditur, mente, conſilioque divino omnia in hoc mundo ad
‘ ſalutem omnium, conſervationemque admirabiliter adminiſtrari.’ Cic. de Nat. Deorum. l. 2. c. 53.

[g] The acute Dr. Cheyne, in his ingenious Philoſ. Princ. of Natural Religon, among other uſes of day and night, ſaith, the night is moſt proper for ſleep; becauſe when the ſun is above the horizon, ſleep is prejudicial, by reaſon the perſpirations are then too great. Alſo that nutrition is moſtly if not altogether, performed in time of reſt; the blood having too quick a motion in the day; for which reaſon, weak perſons, children, &c. are nouriſhed moſt, and recruited beſt by ſleep.

CHAP. IV.

OF THE PLACE AND SITUATION OF THE TERRAQUEOUS GLOBE, IN RESPECT OF THE HEAVENLY BODIES.

ANOTHER thing very conſiderable in our globe is its place and ſituation at a due diſtance from the ſun [h], its fountain of light and heat; and from its neighbouring planets of the ſolar ſyſtem, and from the fixed ſtars. But theſe things I have ſpoken more largely of in my Survey of the Heavens [i], and therefore only barely mention them now, to inſiſt more largely upon.

---

[h] It is a manifeſt ſign of the Creator's management and care, in placing the terraqueous globe at that very diſtance it is from the ſun, and contempering our own bodies, and all other things, ſo duly to that diſtance. For, was the earth farther from the ſun, the world would be ſtarved and frozen with cold: and was it nigher, we ſhould be burnt, at leaſt the moſt combuſtible things would be ſo, and the world would be vexed with perpetual conflagrations. For we ſee that a few of the rays of the ſun, even no more than what falls within the compaſs of an half inch or an inch in a burning-glaſs will fire combuſtible bodies, even in our own climate,

[i] Aſtro-Theology, book vii. chap. 7.

CHAP.

CHAP. V.

THE DISTRIBUTION OF THE EARTH AND WATERS.

THE diſtribution of the waters, and the dry land although it may ſeem rude and undeſigned to a careleſs view, and is by ſome taxed as ſuch [k] yet is admirably well adjuſted to the uſes and conveniences of our world.

---

[k] The moſt eminent author I have met with, that finds fault with the diſtribution of the earth and waters, and indeed with the whole preſent ſtructure of the globe, is the learned and eloquent theoriſt, Dr. Burnet, who frequently exclaims on this point: 'Tellus noſtra, ſi totam ſimul complectamur, non eſt ordinata et venuſta, rerum compages—ſed moles aggeſta vario, incertoque ſitu partium nulla ordinis aut venuſtatis habita ratione.' Theor. Sacr. l. 1. c. 7. 'Ecquis autem a Deo hæc ita facta?' etc. ib. 'Quo autem Herculeo labore opus eſſet ad excavandam terram in tantum hiatum?—Si immediate a cauſa prima effectus fuiſſet hic alveus aliquem ſaltem ordinem, menſuram, et proportionem notare voluiſſet in ipſius forma, et partium diſpoſitione;—ſed confuſa omnia, etc. ib. c. 8. Tellus noſtra cum exigua ſit? eſt etiam rudis: et in illa exiguitate multa ſunt ſuperflua, multa inelegantia. Dimidiam terræ ſuperficiem inundat oceanus; magna ex parte, ut mihi videtur, inutilis.' And then he goes on to ſhew how this part of the creation might be mended, ib. c. 10. All this is to me ſurprizing from an author of great ingenuity, who ſeems, in his book, to have a juſt opinion of, and due veneration for God. But certainly ſuch notions are very inconſiſtent with the belief of God's creating, eſpecially his governing and ordering the world. But ſuppoſe the terraqueous globe was ſuch a rude, confuſed, inconvenient maſs, as he pretends, yet it is well enough for a ſinful world. But beſides, what others have long ago abundantly anſwered, the following ſurvey will, I hope, ſufficiently manifeſt it to be the work of a wiſe and beneficent, as well as omnipotent Creator.

For in the firſt place, the diſtribution is ſo well made, the earth and waters ſo handſomely, ſo workman-like laid, every where all the world over, that there is a juſt equipoiſe of the whole globe. The northern balanceth the ſouthern ocean, the Atlantick the Pacifick ſea. The American dry land is a counterpoiſe to the European, Aſiatick and African.

In the next place, the earth and the waters are ſo admirably well placed about in the globe, as to be helpful to one another, to miniſter to one another's uſes. The great oceans, and the leſſer ſeas and lakes, are ſo admirably well diſtributed throughout the globe[l], as to afford ſufficient vapours[m]

for

---

[l] SOME have objected againſt the diſtribution of the earth and waters, as if the waters occupied too large a part of the globe, which they think would be of greater uſe, if it was dry land. But then they do not conſider that this would deprive the world of a due quantity of vapours and rain. For if the cavities which contain the ſea and other waters, were deeper, although the waters were no leſs in quantity, only their ſurfaces narrower and leſſer, the evaporations would be ſo much the leſs, inaſmuch as thoſe evaporations are made from the ſurface, and are conſequently in proportion to the ſurface, not the depth or quantity of water.

[m] I TOOK notice before, in book I. chap. III. note c p. 26. that the vapours conſtituting clouds and rain, are veſiculæ of water detached by heat. The manner of which I conceive to be thus; heat being of an agile nature, or the lighteſt of all bodies, eaſily breaks looſe from them; and if they are humid, in its paſſage, carries along with it particles, or little caſes of the water; which being lighter than air, are buoyed up thereby, and ſwim in it; until

for clouds and rains to temperate the cold[n], of the northern frozen air to cool and mitigate the heats

---

until by knocking againſt one another, or being thickened by the cold, as in the note before cited they are reduced into clouds and drops.

Having mentioned the manner how vapours are raiſed, and there being more room here than in the note before-cited, I ſhall for the illuſtration of nature's proceſs, take notice of three things obſervable to our purpoſe, in water over the fire. 1. That the evaporations are proportional to the heat aſcending out of the water. A ſmall heat throws off but few vapours, ſcarce viſible: a greater heat and aſcending in greater quantities, carries off groſſer, larger, and more numerous veſiculæ, which we call a ſteam; and if the heat breaks through the water with ſuch a fury, as to lacerate and lift up great quantities or bubbles of water, too heavy for the air to carry or buoy up, it cauſeth what we call boiling. And the particles of water thus mounted up by the heat, are viſible ſphærules of water, if viewed with a microſcope, as they ſwim about in a ray of the ſun let into a dark room, with warm water underneath; where ſome of the vapours appear large, ſome ſmaller ſphærules, according no doubt to the larger and leſſer quantities of heat blowing them up and carrying them off. 2. If theſe vapours be intercepted in their aſcent by any context, eſpecially cold body, as glaſs, marble, &c. they are thereby reduced into drops, and maſſes of water, like theſe of rain, &c. 3. Theſe vapours in their aſcent from the water, may be obſerved, in cold froſty weather, either to riſe but a little above the water, and there to hang or to glide on a little above its ſurface: or if the weather be very cold, after a little aſcent, they may be ſeen to fall back again into the water; in their aſcent and deſcent deſcribing a curve ſomewhat like that of an arrow from a bow. But in a warmer air, and ſtill, the vapours aſcend more nimbly and copiouſly, mounting up aloft till they are out of ſight. But if the air be warm and windy too, the vapours are ſooner carried out of ſight, and make way for others. And accordingly I have often obſerved, that hot liquors, if not ſet too thin, and not frequently ſtirred, cool ſlower in the greateſt froſts, than in temperate weather, eſpecially if windy. And it is manifeſt by good experiments, that the evaporations are leſs at thoſe times than theſe; leſs by far in the winter than the warmer months.

[n] As our northern iſlands are obſerved to be more temperate than our continents, (of which we had a notable inſtance in the great froſt 1708-9, which Ireland and Scotland felt leſs of than

heats [o] of the torrid zone, and to refreſh the earth with fertile ſhowers; yea, in ſome meaſure to miniſter freſh waters to the fountains and rivers. Nay, ſo abundant is this great bleſſing, which the moſt

---

than moſt part of Europe beſides; of which ſee book iv. chap. 12. So this temperature is owing to the warm vapours, afforded chiefly by the ſea, which, by the preceding note, muſt neceſſarily be warm, as they are vapours, or water inflated by heat.

THE cauſe of this heat, I take to be partly that of the ſun and partly ſubterraneous. That it is not wholly that of the ſun, is manifeſt from vapours, being as much or more copiouſly, raiſed, when the ſun-beams are weakeſt, as when ſtrongeſt, there being greater rains and winds at the one time, than the other. And that there is ſuch a thing as ſubterraneous heat; (whether central, or from the meeting of mineral juices; or ſuch as is congenial, or connatural to our globe, I have not time to inquire; but I ſay, ſuch a thing is, (evident not only from the hot-baths, but many fiery eruptions and exploſions, &c. but alſo, from the ordinary warmth of cellars and places under ground, which are not barely comparatively warm, but of ſufficient heat to raiſe vapours alſo: as is manifeſt from the ſmoaking of perennial fountains in froſty weather, and water drawn out of pumps and open wells at ſuch a time. Yea, even animals themſelves, are ſenſible of it, as particularly moles, who dig before a thaw, and againſt ſome other alterations of the weather; excited no doubt, thereunto, by the ſame warm vapours ariſing in the earth which animate them, as well as produce the ſucceeding changes of the weather.

[o] BESIDES the trade-winds, which ſerve to mitigate the exceſſive heats in the torrid zone, the clouds are a good ſcreen againſt the ſcorching ſun-beams, eſpecially, when the ſun paſſeth their zenith; at which time is their winter, or cooleſt ſeaſon,

indulgent Creator, hath afforded us, by means of this diſtribution of the waters, I am ſpeaking of, that there is more than a ſcanty, bare proviſion, or mere ſufficiency; even a plenty, a ſurpluſage of this uſeful creature of God, the freſh waters, afforded to the world; and they ſo well ordered, as not to drown the nations of the earth, nor, to ſtagnate, ſtink, and poiſon or annoy them; but to be gently carried through convenient channels back again to their grand fountain the ſea[p] and many of

---

by reaſon they have then moſt clouds and rain. For which ſervice, that which Varene takes notice of, is a great providence of God, viz. 'Pleraque loca zonæ torridæ vicinum habent mare, ut India, 'inſulæ Indicæ, lingua Africæ, Guinea, Braſilia, Peruvia, Mexicana, 'Hiſpania: pauca loca zonæ torridæ ſunt Mediterranea.' Varenii Geogr. l. 2. c, 26. prop. 10 ſect. 7.

[p] THAT ſprings have their origin from the ſea, and not from rains and vapours, among many other ſtrong reaſons, I conclude from the perennity of divers ſprings, which always afford the ſame quantity of water. Of this ſort there are many to be found every where. But I ſhall for inſtance, ſingle out one in the pariſh of Upminſter, where I live, as being very proper for my purpoſe, and one, that I have had better opportunities of making remarks upon above twenty years. This in the greateſt droughts is little, if at all diminiſhed, that I could perceive by my eye, although the ponds all over the country, and an adjoining brook, have been dry for many months together; as particularly in the dry ſummer months of the year 1705. And in the wetteſt ſeaſons, ſuch as the ſummer and other months, were, preceding the violent ſtorm in November 1703, (Vide Philoſ. Tranſ. No. 289.) I ſay, in ſuch wet ſeaſons, I have not obſerved any increment of its ſtream, excepting only from violent rains falling therein,

of them through ſuch large tracts of land, and to ſuch prodigious diſtances, that it is a great won-

therein, or running down from the higher land into it; which diſcoloureth the waters oftentimes, and makes an increaſe of only a day's, or ſome times, but a few hours continuance. But now, if this ſpring had its origin from rain and vapours, there would be an increaſe, and decreaſe of the one, as there ſhould happen to be of the other; as actually it is, in ſuch temporary ſprings as have undoubtedly their ſource from rain and vapours.

But beſides this, another conſiderable thing in this Upminſter ſpring, and thouſands of others, is, that it breaks out of ſo inconſiderable an hilloc, or eminence of ground, that can have no more influence in the condenſation of the vapours, or ſtopping the clouds, (which the maintainers of this hypotheſis ſuppoſe) than the lower lands about it have. By ſome critical obſervations I made with a very nice portable barometer, I found that my houſe ſtands between 80 and 90 feet higher than the low-water mark in the river of Thames, neareſt me; and that part of the river being ſcarce thirty miles from the ſea, I gueſs, (and am more confirmed from ſome later experiments I made nearer the ſea) that we cannot be much above 100 feet above the ſea. The ſpring I judge nearly level with, or but little higher than where my houſe ſtands; and the lands from whence it immediately iſſues, I gueſs about 15 or 20 feet higher than the ſpring; and the lands above that, of no very remarkable height. And indeed, by actual meaſure, one of the higheſt hills I have met with in Eſſex, is but 363 feet high; (Vide Philoſ. Tranſ. N°. 313. and I gueſs, by ſome very late experiments I made, neither that, nor any other land in Eſſex, to be above 400 feet above the ſea. Now, what is ſo inconſiderable a riſe of land to a perennial condenſation of vapours, fit to maintain even ſo inconſiderable a fountain, as what I have mentioned is? or indeed the high-lands of the whole large county of Eſſex, to the maintaining of all its fountains and rivulets?

But I ſhall no farther proſecute this argument, but refer to the late der the fountains ſhould be high enough [q], or the ſeas low enough, ever to afford ſo long a conveyance. Witneſs the Danube [r] and Wolga

---

late learned, curious, and induſtrious Dr. Plot's Tentamen Phil. de Orig. Font. in which he hath fully diſcuſſed this matter.

As to the manner how the waters are raiſed up into the mountains and higher lands, an eaſy and natural repreſentation may be made of it, by putting a little heap of ſand, aſhes, or a little loaf of bread, &c. in a baſon of water: where the ſand will repreſent the dry land, or an iſland, and the baſon of water the ſea about it. And as the water in the baſon riſeth to, or near the top of the heap in it, ſo do the waters of the ſea, lakes, &c. riſe in the hills. Which caſe I take to be the ſame with the aſcent of liquids in capillary tubes, or between contiguous planes, or in a tube filled with aſhes: of which the induſtrious and complete artificer in air-pumps, Mr. Hawkſbee, hath given us, ſome not contemptible experiments, in his Phyſ. Mech. Exp. p. 139.

AMONG the many cauſes aſſigned for this aſcent of liquors, there are two that bid the faireſt for it, viz. the preſſure of the atmoſphere, and the Newtonian attraction. That it is not the former, appears from the experiments ſucceeding, as well, or better, in vacuo, than in the open air, the aſcent being rather ſwifter in vacuo. This then being not the cauſe, I ſhall ſuppoſe the other is; but for the proof thereof I ſhall refer to ſome of our late Engliſh authors, eſpecially ſome very late experiments made before our moſt famous Royal Society, which will be ſo well improved by ſome of that illuſtrious body, as to go near to put the matter out of doubt.

[q] SEE book iii. chap. 4.

[r] THE Danube, in a ſober account, performs a courſe of ' above 1500 miles, (i. e. in a ſtrait line) from its riſe to its fall. Bohun's Geogr. Dict.

s ' Trac-

Wolga of Europe, the Nile [s], and the Niger [t] of Africa, the Ganges [u], and Euphrates of Aſia, and the Amazons River [v], and Rio de la Plata of America, and many others which might be named; ſome of which are ſaid to run above 5000 miles, and ſome no leſs than 6000 from their fountains to the ſea. And indeed ſuch prodigious conveyances of the waters make it manifeſt, that no accidental currents and alterations of the waters themſelves, no art or power of man, nothing leſs than the Fiat of the Almighty, could ever have made, or found, ſo long and commodious declivities, and channels for the paſſage of the waters.

---

[s] 'Tractus ſc. longitudo [Nili] eſt milliarium circiter 630 'Germ. ſive Ital. 2520, pro quibus ponere licet 3000 propter 'curvaturas.' Varen. Geogr. l. 1. c. 16. p. 27.

[t] Varene reckons the courſe of the Niger, at a middle computation, 600 German miles, that is 2400 Italian.

[u] THAT of the Ganges he computes at 300 German miles But if we add the curvatures of theſe rivers, their channels are of a prodigious length.

[v] 'Oritur flumen (quod plerumque Amazonum, &c.) haud 'procul Quito in montibus——Cum per leucas Hiſpanicas 1356. 'curſum ab occidente in orientem continuarit, oſtio 84 leucas 'lata—in oceanum præcipitatur. Chr. D'Acugna relatio de flumine Amaz. in Act. Erud. Aug. 1683.

CHAP. VI.

THE GREAT VARIETY AND QUANTITY OF ALL THINGS UPON, AND IN THE TERRAQUEOUS GLOBE, PROVIDED FOR THE USES OF THE WORLD.

THE laſt remark I ſhall make about the terraqueous globe in general is, the great variety of kinds, or tribes, as well as prodigious number of individuals of each various tribe, there is of all creatures [w]. There are ſo many beaſts, ſo

---

[w] ‘Non dat Deus beneficia? Unde ergo iſta quæ poſſides? —Unde hæc innumerabilia, oculos, aures et animum mulcentia? Unde illa luxuriam quoque inſtruens copia? Neque enim neceſſitatibus tantummodo noſtris proviſum eſt: uſque in delicias amamur. Tot arbuſta, non uno modo frugifera, tot herbæ ſalutares, tot varietates ciborum, per totum annum, digeſtæ, ut inerti quoque fortuita terræ alimenta præberent. Jam animalia omnis generis, alia in ſicco, &c.———ut omnis rerum naturæ pars tributum aliquod nobis conferret.’ Senec. de Benef. l. 4. c. 5. ubi plura vide.

‘Hic, ubi habitamus, non intermittit ſuo tempore cœlum niteſcere, arbores frondeſcere——tum multitudinem pecudum partim ad veſcendum, partim ad cultus agrorum, partim ad vehendum, partim ad corpora veſtienda; hominemque ipſum quaſi contemplatorem cœli ac deorum, ipſorumque cultorem. ——Hæc ſo many birds, ſo many inſects, ſo many reptiles, ſo many trees, ſo many plants upon the land; ſo many fiſhes, ſea-plants and other creatures in the waters; ſo many minerals, metals, and foſſiles in the ſubterraneous regions; ſo many ſpecies of theſe genera, ſo many individuals of thoſe ſpecies, that there is nothing wanting to the uſe of man, or any other creature of this lower world. If every age doth change its food, its way of cloathing, its way of building; if every age [x] hath its variety of diſeaſes; nay, if man, or any other animal, was minded to change thoſe things every day, ſtill the creation would not be exhauſted, ſtill nothing would be wanting for food, nothing for phyſic, nothing for building and habitation, nothing for cleanlineſs and refreſhment, yea, even for recreation and pleaſure. But the munificence of the Creator is ſuch, that there is abundantly enough to ſup-

---

'——Hæc igitur, et alia innumerabilia cum cernimus, poſſumuſne dubitare, quin his præſit aliquis vel effector, ſi hæc 'nata ſunt, ut Platoni videtur: vel ſi ſemper fuerint, ut Ariſto'teli placet, moderator tanti operis et muneris?' Cic. Tuſc. Quæſt. l. 1. c. 28 and 29.

[x] 'Sunt et gentium differentiæ non mediocres—quæ con'templatio aufert rurſus nos ad ipſorum animalium naturas, ingenitaſque iis vel certiores morborum omnium medicinas. Enim 'vero rerum omnium parens nullum animal ad hoc tantum ut 'paſceretur, aut alia ſatiaret, naſci voluit: arteſque ſalutares iis inſeruerit.' Plin. Nat. Hiſt. l. 27. c. 13.

ply the wants, the conveniencies, yea, almoſt the extravagancies of all the creatures, in all places, all ages and upon all occaſions.

And this may ſerve to anſwer an objection againſt the excellency of, and wiſdom ſhewed in, the creation; namely, what need of ſo many creatures [y]? Particularly of ſo many inſects, ſo many plants,, and ſo many other things? and eſpecially of ſome of them, that are ſo far from being uſeful, that they are very noxious; ſome by their ferity, and others by their poiſonous nature &c.

---

[y] This was no very eaſy queſtion to be anſwered by ſuch as held, that 'all things were made for man; as moſt of the ancients did; as Ariſtotle, Seneca, Cicero, and Pliny, (to name only ſome of the chief). And Cicero cites it as the celebrated Chryſippus's opinion, 'Præclare enim Chryſippus, cætera nata 'eſſe hominum cauſa, et deorum.' De fin. bon. et mal. l. 3. And in his De Nat. Deor. l. 2. fin. he ſeriouſly proves the world itſelf to have been made for the gods and men, and all things in the world to have been made and contrived for the benefit of man, parata et inventa ad fructum hominum,' are his words. So Pliny, in his preface to his 7th book, ſaith nature made all things for man; but then he makes a doubt whether ſhe ſhewed herſelf a more indulgent parent, or cruel ſtep-mother, as in book iv. chap. 12. note 2. But ſince the works of God have been more diſcovered, and the limits of the univerſe have been found to be of infinitely greater extent than the ancients ſuppoſed them; this narrow opinion hath been exploded. And the anſwer will be found eaſy to theſe queſtions why ſo many uſeleſs creatures? In the heavens, why ſo many fixed ſtars, and the greateſt part of them ſcarce viſible? why ſuch ſyſtems of planets as in Jupiter, Saturn, &c. (See my Aſtro-Theology.) In the earth and waters, why ſo many creatures of no uſe to man?

To which I might anſwer, that in great variety, the greater art is ſeen; that the fierce, poiſonous, and noxious creatures ſerve as rods and ſcourges to chaſtiſe us [z], as means to excite our wiſdom, care, and induſtry, with more to the ſame purpoſe. But theſe things have been fully urged by others; and it is ſufficient to ſay, that this great variety is a moſt wiſe proviſion for all the uſes of the world in all ages, and all places. Some for food, ſome for phyſic

---

[z] 'Nec minus clara exitii documenta ſunt etiam ex contemnendis animalibus. M. Varro author eſt a cuniculis ſuffoſſum in Hiſpania oppidum, a talpis in Theſſalia: ab ranis civitatem in Gallia pulſam, ab locuſtis in Africa: ex Gyaro Cycladum inſula, incolas a muribus fugatos: in Italia Amyclas a ſerpentibus deletas. Citra Cynamolgos Æthiopas late deſerta regio eſt, a ſcorpionibus et ſolpugis gente ſublata: et a ſcolopendris abactos Trerienſes, auctor eſt Theophraſtus.' Plin. Nat. Hiſt. l. 8. c. 29.

To theſe inſtances may be added, the plague they ſometimes ſuffer from a kind of mice (they call Leming, Leminger, Lemus, etc.) in Norway, which eat up every green thing. They come in ſuch prodigious numbers, that they fancy them to fall from the clouds; but Ol. Magnus rather thinks they come from ſome of the iſlands, Hiſt. l. 8. c. 2. If the reader hath a mind to a large account of them with a diſpute about their generation, a handſome cut of them, with the prayers, and an exorciſm againſt them uſed in the church of Rome, I ſhall refer him (it being too tedious to recite in theſe notes) to Muſæum Wormian. l. 3. c. 23.

'Quare patimur multa mala a creatura quam fecit Deus, niſi quia offendimus Deum?--De pœna tua peccatum tuum accuſa, non judicem. Nam propter ſuperbiam inſtituit Deus creaturam iſtam minimam et abjectiſſimam, ut ipſa nos torqueret, ut cum ſuperbus fuerit homo, et ſe jactaverit adverſus deum,—cum ſe erexerit, pulicibus ſubdatur. Quid eſt quod te inflat humana ſuperbia?

'ſuperbia? Pulicibus reſiſte ut dormias. Cognoſce qui ſis. Nam 'propter ſuperbiam noſtram domandam—creata illa quæ moleſta 'ſunt: populum Pharaonis ſuperbum potuit Deus domare de urſis 'etc. Muſcas et ranas illas immiſit, ut rebus viliſſimis ſuperbia 'domaretur. Omnia ergo per ipſum—facta ſunt; et ſine ipſo factum 'eſt nihil.' Aug. Tract. 1. in S. Joh.

But although the infinitely wiſe Creator hath put it in the power of ſuch vile animals to chaſtiſe us, yet hath he ſhewed no leſs wiſdom and kindneſs in ordering many, if not moſt of them ſo, as that it ſhall be in the power of man, and other creatures, to obviate or eſcape their evils. For, beſides the noble antidotes afforded by minerals, vegetables, etc. many, if not moſt of our European venomous animals carry their cure, as well as poiſon in their own bodies. The oil, and I doubt not, the body of ſcorpions too, is a certain remedy againſt its ſtroke. A bee, waſp, or hornet, cruſhed and rubbed, and bound upon the place, I have always found to be a certain cure for the ſting of thoſe creatures. And I queſtion not, but the fleſh, eſpecially the head, of vipers, would be found a remedy for their bites.

'Our viper-catchers have a remedy, in which they place ſo great 'a confidence, as to be no more afraid of the bite [of a viper] than 'of a common puncture, immediately curing themſelves by the 'application of their ſpecific. This though they keep a ſecret, I 'have, upon ſtrict inquiry, found to be no other than Axungia 'Viperina, preſently rubbed into the wound.' This remedy the learned doctor tried himſelf with good ſucceſs, on a young dog that was bitten in the noſe. Vide Mead of Poiſons, p. 29.

And as to the means to eſcape the miſchief of ſuch noxious animals, beſides what may be effected by the care, induſtry, and ſagacity of man; ſome of them are ſo contrived and made, as to give phyſic [a], ſome for habitation, ſome for utenſils, ſome for tools and inſtruments of work, and ſome for recreation and pleaſure, either to man, or to ſome of the inferior creatures themſelves; even for which inferior creatures the liberal Creator hath provided all things neceſſary, or any ways conducing to their happy, comfortable living in this world as well as for man.

And it is manifeſt, that all the creatures of God, beaſts, birds, inſects, plants, and every other genus

---

warning or time to creatures in danger from them. Thus for inſtance the rattle-ſnake, the moſt poiſonous of any ſerpent, who darts its poiſonous vapours to ſome diſtance, and in all probability was the baſiliſk of the antients, ſaid to kill with its eyes; this involuntarily gives warning by the rattle in its tail. So the ſhark, the moſt rapacious animal of the waters, is forced to turn himſelf on his back, and thereby gives an opportunity of eſcape, before he can catch his prey.

[a] 'HÆC ſola naturæ placuerat eſſe remedia parata vulgo, inventu facilia, ac ſine impendio, ex quibus vivimus. Poſtea fraudes hominum et ingeniorum capturæ officinas invenire iſtas, in quibus ſua cuique homini venalis promittitur vita. Statim compoſitiones et miſturæ inexplicabiles decantantur. Arabia atque India in medio æſtimantur, ulcerique parvo medicina a Rubro mari importatur, cum remedia vera quotidie pauperrimus quiſque cœnet.' Plin. l. 24, c. 1.

'NON ſponte ſua ex tellure germinant herbæ, quæ contra quoſcunque morbos accomodatæ ſunt; ſed eæ voluntate opificis, ad noſtram utilitatem producta ſunt.' Baſil. Aſcet. Tom. 2.

CONSULT here book x.

have, or may have, their ſeveral uſes even among men: For although in one place, many things may lie neglected, and out of uſe yet, in other places they may be of great uſe. So what hath ſeemed uſeleſs in one age, hath been received in another; as all the new diſcoveries in phyſic, and all the alterations in diet do ſufficiently witneſs. Many things alſo there are, which in one form may be pernicious to man; but in another of great uſe. There are many plants, [b] many animals, many minerals, which in one form deſtroy, in another heal. The Caſſada plant, unprepared, poiſoneth, but

---

[b] AMONG poiſonous vegetables, none more famous of old than hemloc, accounted at this day alſo very dangerous to man; of which there are ſome diſmal examples in our Philoſ. Tranſ. Wepfer, &c. But yet this plant is food for goats, and its ſeeds to buſtards; and as Galen ſaith, to ſtarlings alſo. Neither is this ſo pernicious a plant, only food, but alſo phyſic to ſome animals. An horſe troubled with the farcy, and could not be cured with the moſt famous remedies, cured himſelf of it in a ſhort time, by eating hemlock, of which he eat greedily. Vide Phil. Tranſ, No. 231. 'And a woman which was cured of the 'plague, but wanted ſleep, did with very good effect, eat hem-'lock for ſome time; till falling ill again of a fever, and having 'left off the uſe of this remedy, he [Nic Fontanus] endeavoured to 'procure her reſt by repeated doſes of opium, which had no opera-'tion, till the help of cicuta was again called in with deſired ſuc-'ceſs.' Mead of Poiſ. p. 144.

AND not only hemloc, but many other, if not moſt plants accounted poiſonous. may have their great uſe in medicine: of which take the opinion of a noble judge, my ingenius and learned friend but prepared is the very bread of the Weſt-Indies [c] Vipers and ſcorpions, and many minerals, as deſtructive as they are to man, yet afford him ſome of his beſt medicines.

---

friend, Dr. Tancred Robinſon, in a letter I have of his to the late great Mr. Ray, of Nov. 7, 1664. viz. ' According to my promiſe ' I here ſend you a few obſervations concerning ſome plants ſeldom ' uſed in medicine, being eſteemed poiſonous, which if truly cor- ' rected, or exactly doſed, may perhaps prove the moſt powerful, ' and effectual medicines yet known.' Having then giving an account of ſome of their correctives, he gives theſe following examples, viz. 1. ' The hellebores incorporated with a ſapor or ' alkaly-ſalts alone, are ſucceſsful remedies in epilepſies, vertigos, ' palſies, lethargies, and manias. Doſ. a ℈ j. to ʒ ß. 2. The ' Radic. Aſſari, cicutæ, and the napellus, in agues, and periodi- ' cal pains. Doſ. ℈ j. ʒ ß 3. The Hyoſcyamus in Hæm- ' morrhages violent heat and perturbation of the blood, and alſo ' in all great inflammations. Doſ. ℈ j. to ʒ ß 4. The ſemen ' Stramoniæ, is a very good anodyne, uſeful in vigilias, rheuma- ' tiſms, hyſteric caſes, in all the orgaſms of the blood or ſpirits, and ' wherever there is an indication for a paregoric. Doſ. ʒ j. to ʒ ß ' 5. Elaterium thus corrected, may be given from gr. x. to xv. ' in hydropical caſes, without any ſenſible evacuation or diſturb- ' ance. So may the Soldanella, and Gratiola in greater doſes: 6. ' Opium corrected as afore-mentionod loſes its narcotic faculty, ' and may be given very ſafely in great doſes, and proves more ' than uſually prevalent in convulſive caſes, fluxes, catarrhs, and ' all painful paroxyſms, &c.'

' ' It is of the moſt general uſe of any proviſion all over the ' Weſt-Indies, eſpecially in the hotter parts, and is uſed to vic- ' tual ſhips.' Dr. Sloan's Nat. Hiſt. of Jamiaca, vol. ch. 5. ſect. 12.

OR if there be many things, of little immediate uſe to man, in this, or any other age; yet to other creatures they may afford food or phyſic, or be of ſome neceſſary uſe. How many trees and plants, nay, even the very carcaſes of animals, yea, the very duſt of the earth [d], and the moſt refuſe, contemptible things to be met with; I ſay, how many ſuch things are either food, or probably medicine to many creatures, afford them retreat, are places of habitation, or matrixes for their generation, as ſhall be ſhewed in proper place! The prodigious ſwarms of inſects in the air, and in the waters, (many of which, may be perhaps, at preſent, of no great uſe to man) yet are food to birds, fiſhes, reptiles, inſects, themſelves, and other creatures for whoſe happy and comfortable aſſiſtance, I have ſaid the bountiful Creator hath liberally provided as well as for that of man.

---

[d] I HAVE ſhewn in the Phil. Tranſ. that the pediculus fatidicus, mortiſaga pulſatorius, or death-watch, there deſcribed, feedeth upon duſt; but that this duſt they eat is powdered bread, fruits, or ſuch like duſt, not powdered earth; as is manifeſt from their great diligence and curioſity in hunting among the duſt. See more in Phil, Tranſ. No. 291.

BOOK III.

OF THE TERRAQUEOUS GLOBE IN PARTICULAR; MORE ESPECIALLY THE EARTH.

HAVING thus taken a general proſpect of our terraqueous globe, I ſhall in this book come to its particulars. But here we have ſuch an immenſe variety preſenting itſelf to our ſenſes, and ſuch amazing ſtrokes of power and wiſdom, that it is impoſſible not to be at a ſtand, and very difficult to know where to begin, how to proceed, or where to end. But we muſt however attempt.

AND for the more clear, and regular proceeding on this copious ſubject, I ſhall diſtribute the globe into its own grand conſtituent parts.

I. THE earth and its appurtenances.

II. THE waters and theirs.

THE firſt of theſe only, is what at preſent I ſhall be able to take into this ſurvey.

AND in ſurveying the earth, I intend,

I. To conſider its conſtituent parts, or things peculiar to itſelf.

II. THE inhabitants thereof, or the ſeveral kinds of creatures that have their habitation, growth or ſubſiſtence thereon.

I. As to the earth itſelf, the moſt remarkable things that preſent themſelves to our view, are,

I. ITS various moulds and ſoils.

II. ITS ſeveral ſtrata, or beds.

III. ITS very ſubterraneous paſſages, grottos, and caverns.

IV. ITS mountains and vallies.

CHAP.

CHAP. I.

OF THE SOILS AND MOULDS IN THE EARTH.

THE various ſoils and moulds, are an admirable and manifeſt contrivance of the all-wiſe Creator, in making this proviſion for the various vegetables [e] and divers other uſes of the creatures. For, as ſome trees, ſome plants, ſome grains, dwindle and die in a diſagreeable ſoil, but thrive and flouriſh in others; ſo the all-wiſe Creator hath amply provided for every kind a proper bed.

If ſome delight in a warm, ſome in a cold ſoil; ſome in a lax or ſandy, ſome a heavy or clayey ſoil; ſome in a mixture of both, ſome in this, and

---

[e] It is not to be doubted, that although vegetables delight in peculiar ſoils, yet they owe not their life and growth to the earth itſelf, but to ſome agreeable juices or ſalts, &c. reſiding in the earth. Of this the great Mr. Boyle hath given us ſome good experiments. He ordered his gardener, to dig up and dry in an oven, ſome earth fit for the purpoſe, to weigh it, and to ſet therein, ſome ſquaſh ſeeds. (a kind of Indian pompion.) The ſeeds when ſown, were watered with rain or ſpring-water only. But although a plant was produced in one experiment of near 3 lb and in

that, and the other mould, ſome in moiſt, ſome in dry places [f] ſtill we find proviſion for all theſe purpoſes: every country abounding with its proper trees and plants [g] and every vegetable flouriſhing and gay, ſomewhere or other about the globe, and abundantly anſwering the almighty command of the Creator, when the earth and waters were ordered

---

another of above 14 lb. yet the earth when dried, and weighed again, was ſcarce diminiſhed at all in its weight.

Another experiment he alledges is of Helmont's, who dried 200 lb. of earth, and therein planted a willow weighing 5 lb. which he watered with rain, or diſtilled water: and to ſecure it from any other earth getting in, he covered it with a perforated tin-cover. After five years, weighing the tree with all the leaves it had born in that time, he found it to weigh 169 lb. 3 oz; but the earth to be diminiſhed only about 2 oz. in its weight. Vide Boyle's Sept. Chim. part 2.

[f] Τὰς δὲ τόπους ζητεῖ τοὺς οἰκείους, οὐ μόνον τὰ περιττὰ—Τῶν δένδρων. etc Τὰ μὲν γὰρ φιλεῖ ξηροὺς, τὰ δὲ ἐνύδρους, τὰ δὲ χειμερινοὺς, τὰ δὲ προσηλίους, τὰ δὲ παλισκίους, και ὅλως, τὰ μὲν ὀρεινοὺς τὰ δὲ ἑλώδεις.—Ζητεῖ γὰρ τα πρότερα κατὰ τὴν κρασιν, ἔτι δὲ ασθενῆ και ἰσχυρὰ, και βαθύρριζα, και ἐπιπολαιόρριζα, και εἴτις ἄλλη διαφορὰ, κατὰ τὰ μέρη—Πάντα γὰρ ταῦτα, ἔτι δὲ τὰ ομοια ζητεῖ τὸ ὅμοιον, και τα ἀνόμοια μὴ τὸν αὐτὸν, ὅταν ἦ τις παραλλαγὴ τῆς φύσεως. Theophraſt. de Cauſ Plant. l. 2. c. 9.

[g] Nec vero terræ ferre omnes omnia poſſunt.
Fluminibus Salices, craſſiſque paludibus Alni
Naſcuntur: ſteriles ſaxoſis montibus Orni:
Littora Myrtetis lætiſſima: denique apertos
Bacchus amat colles, Aquilonem et frigora Taxi.
Aſpice et extremis domitum cultoribus orbem,
Eoaſque domos Arabum, pictoſque Gelonos:
Diviſæ arboribus patriæ, etc. Virg. Georg. l. 2.

dered to their peculiar place, Gen. I. II. ‘ And ‘ God ſaid, let the earth bring forth graſs, the ‘ herb yielding ſeed, and the tree yielding fruit ‘ after his kind.’ All which we actually ſee is ſo.

To this convenience which the various ſoils that coat the earth are of to the vegetables, we may add their great uſe and benefit to divers animals, to many kinds of quadrupeds, fowls, inſects, and reptiles, who make in the earth their places of repoſe and reſt; their retreat in winter, their ſecurity from their enemies, and their neſt to repoſe their young; ſome delighting in a lax and pervious mould, admitting them an eaſy paſſage; and others delighting in a firmer and more ſolid earth, that will better ſecure them againſt injuries from without.

CHAP. II.

OF THE VARIOUS STRATA, OR BEDS, OBSERVABLE IN THE EARTH.

THE various Strata, or Beds although but little different from the laſt, yet will deſerve a diſtinct conſideration

By the Strata, or Beds, I mean thoſe layers of minerals [h], metals [i], earth and ſtone [k], lying under

---

[h] Although minerals, metals, and ſtones lie in beds, and have done ſo ever ſince Noah's flood, if not from the creation; yet it is greatly probable, that they have power of growing in their reſpective beds: that as the beds are robbed and emptied by miners, ſo after a while they recruit again. Thus vitriol, Mr. Boyle thinks, will grow by the help of the air. So allum doth the ſame. 'We are aſſured (he ſaith) by the experienced Agricola, 'that the earth, or ore of allum, being robbed of its ſalt, will 'in a tract of time recover it, by being expoſed to the air.' Boyle Suſpic, about ſome hid. Qual. in the Air, p. 18.

[i] As to the growth of metal, there is great reaſon to ſuſpect that alſo, from what Mr. Boyle hath alleged in his Obſervations about the growth of Metals; and in his Scept. Chym. part 6. p. 362. Compare alſo Hakewill's Apol. p. 164.

der that upper ſtratum, or tegument of the earth laſt ſpoke of, all of a prodigious uſe to man-

F 4 kind

And particularly, as to the growth of iron, to the inſtances he gives from Pliny, Fallopius, Cæſalpinus, and others; we may add, what is well known in the foreſt of Dean in Glouceſterſhire; that the beſt iron, and moſt in quantity, that is found there, is in the old cinders, which they melt over again. This the author of the Additions to Glouceſterſhire, in Cambden's Brit. of the laſt edition, p. 245. attributes to the remiſſneſs of the former melters, in not exhauſting the ore: but in all probability, it is rather to be attributed to the new impregnations of the old ore, or cinders, from the air, or from ſome ſeminal principle, or plaſtic quality in the ore itſelf.

[k] As for the growth of ſtone, Mr. Boyle gives two inſtances, one is that famous place in France, called Les Caves Coutieres: Where the water, falling from the upper parts of the cave to the ground, doth preſently there condenſe into little ſtones, of ſuch figure as the drops, falling either ſeverally, or upon one another, and coagulating preſently into ſtones, chance to exhibit. Vid. Scept. Chym. p. 360.

Such like caves as theſe I have myſelf met with in England; particlarly on the very top of Bredon-Hill in Worceſterſhire, near the precipice, facing Perſhore, in or near the old fortreſs, called Bemſbury-Camp; I ſaw ſome years ago ſuch a cave, which, if I miſ-remember not, was lined with thoſe ſtalactical-ſtones on the top and ſides. On the top they hung like icicles great and ſmall, and many lay on the ground. They ſeemed manifeſtly to be made by an exſudation, or exſtillation of ſome petrifying juices out of the rocky earth there. On the ſpot, I thought it might be from the rains ſoaking through, and carrying with it impregnations from the ſtone, the hill being there all rocky Hard by the cave is one or more vaſt ſtones, which, if I miſtake not, are incruſted with this ſparry, ſtalactical ſubſtance, if not wholly made of it. But it is ſo many years ago ſince I was at the place, and not being able to find my notes about it, I cannot ſay whether the whole ſtone is, in all probability, ſpar,

as

kind: ſome being of great uſe for building; ſome ſerving for ornament; ſome furniſhing us with commodious machines and tools to prepare our food, and for veſſels and utenſils, and for multitudes of other uſes; ſome ſerving for firing to dreſs our food, and to guard us againſt the inſults of cold and weather; ſome being of great uſe in phyſic, in exchange and commerce, in manuring and fertilizing our lands, in dying and colouring, and ten thouſand other conveniencies, too many to be particularly ſpoken of; only there is one grand uſe of one of theſe ſtrata, or beds, that cannot eaſily be omitted, and that is, thoſe ſubterraneous ſtrata of ſand, gravel, and laxer earth that admit of, and facilitate the paſſage of the ſweet waters [1], and may probably be the

---

as I think it is, or whether I found it only caſed over with it, notwithſtanding I was very nice in examining it then, and have now ſome of the fragments by me, conſiſting, among other ſhining parts, of ſome tranſparent angular ones.

The other inſtance of Mr. Boyle, is from Linſchoten, who ſaith, that in the Eaſt-Indies, when they have cleared the diamond-mines of all the diamonds, ‘In a few years time they find in ‘the ſame place new diamonds produced.’ Boyle, ibid.

[1] It is not only agreeable to reaſon, but I am told by perſons converſant in digging of wells throughout the county of Eſſex, where I live, that the fureſt beds in which they find water, are gravel, and a coarſe dark coloured ſand; which beds ſeldom fail to yield plenty of ſweet water: but for clay, they never find water therein, if it be a ſtrong, ſtiff clay; but if it be lax and ſandy, ſometimes ſprings are found in it; yet ſo weak, that they will

the colanders whereby they are ſweetened, and then at the ſame time alſo conveyed to all parts of the habitable world, not only through the temperate and torrid zones, but even the fartheſt regions of the frozen poles.

THAT theſe ſtrata are the principal paſſages of the ſweet fountain-waters, is I think, not to be doubted, conſidering that in them the waters are well known to paſs, and in them the ſprings are found by thoſe that ſeek for them: I ſay, the principal paſſages, becauſe there are other ſub-

---

ſcarcely ſerve the uſes of the ſmalleſt family. And ſometimes they meet with thoſe beds lying next, under a looſe, black mould (which, by their deſcription, I judged to be a ſort of oazy, or to have the reſemblance of an ancient, ruſhy ground) and in that caſe the water is always naught, and ſtinks. And laſtly, another ſort of bed they find in Eſſex, in the clayey lands, particularly that part called the Rodings, which yield plenty of ſweet water, and that is a bed of white earth, as though made of chalk and white ſand. This they find, after they have dug through forty, or more, feet of clay; and it is ſo tender and moiſt, that it will not lie upon the ſpade, but they are forced to throw it into their bucket with their hands, or with bowls; but when it comes up into the air, it ſoon becomes an hard white ſtone.

THUS much for the variety of beds wherein the waters are found. That it is in theſe beds only or chiefly the ſprings run, is farther manifeſt from the forcible eruption of the waters ſometimes out of thoſe watery beds. Of which ſee chap. 4. This eruption ſhews, that the waters come from ſome eminence or other, lying at a diſtance, and being cloſe'y pent up within the watery ſtratum by the clayey ſtrata, the waters with force mount up when the ſtrata above are opened.

terraneous guts and channels, fiſſures and paſſages, through which many times the waters make their way.

Now that which in a particular manner doth ſeem to me to manifeſt a ſpecial providence of God in the repoſiting theſe watery beds is, that they ſhould be diſperſed all over the world, into all countries, and almoſt all tracts of land: that they ſhould ſo entirely, or for the moſt part, conſiſt of lax, incohering earth, and be ſo ſeldom blended with other impervious moulds, or if they are ſo, it is commonly but accidentally; and that they are interpoſed between the other impervious beds, and ſo are as a prop and pillar to guard them off, and to prevent their ſinking in and ſhutting up the paſſages of the waters.

The time when thoſe ſtrata were laid, was doubtleſs at the creation, when 'God ſaid (Gen. 'i. 9.) Let the waters under the heavens be 'gathered together unto one place, and let the 'dry land appear or ;' elſe at the deluge, if, with ſome ſagacious naturaliſts, we ſuppoſe the globe of earth to have been diſſolved by the flood [m]. At that time, whatever it was, when the terraqueous globe was in a chaotic ſtate and the earthly

---

[a] Vide Dr. Woodward's Eſſay, part 2. Steno's Prodr. &c.

[b] Id.

earthly particles ſubſided, then thoſe ſeveral beds were, in all probability, repoſited in the earth, in that commodious order in which they now are found; and that, as is aſſerted, according to the laws of gravity [n].

---

[n] Id. ib. 28, and 74. But Dr. Leigh, in his Nat. Hiſtory of Lancaſhire, ſpeaking of the coal-pits, denies the ſtrata to lie according to the laws of gravitation, ſaying, the ſtrata are a bed of marle. afterwards free ſtone, next iron-ſtone, then-coal, or kennel-mine, then ſome other ſtrata, and again coal &c.

BUT upon a ſtricter inquiry into the matter, finding I had reaſon to ſuſpect that few, if any, actually had tried the experiment, I was minded to bring the thing to the teſt of experiment myſelf; and having an opportunity, on April 11. 1712. I cauſed divers places to be bored, laying the ſeveral ſtrata by themſelves? which afterwards I weighed with all ſtrictneſs, firſt in air, then in water, taking care that no air-bubbles, &c. might obſtruct the accuracy of the experiment. The reſult was, that in my yard, the ſtrata were gradually ſpecifically heavier and heavier, the lower and lower they went; and the upper, which was clay, was conſiderably ſpecifically lighter than the lower ſtratum; which was firſt a looſe ſand then a gravel. In which ſtratum principally the ſprings run that ſupply my well.

BUT in my fields, where three places were bored, to no great depth, I found below the upper (ſuperficial ſtratum a deep bed of ſand only, which was of different colours and conſiſtence, which I weighed as before, together with the virgin mould; but they were all of the ſame, or nearly the ſame ſpecific gravity, both out of the ſame hole, and out of different holes although the ſand was at laſt ſo gravelly, that it hindered our boring any deeper.

UPON this, fearing leſt ſome error might be in the former experiments I tried them over again; and that with the ſame ſucceſs.

AFTER this I made ſome experiments in ſome deep chalk-pits with the flints, chalk, &c. above and below; but the ſucceſs was not ſo uniform as before.

ACQUAINTING our juſtly renowned Royal Society with theſe experiments, they ordered their operator to experiment the ſtrata of a coal-pit; the ſucceſs whereby may be ſeen in Phil. Tranſ. No. 336.

CHAP. III.

OF THE SUBTERRANEOUS CAVERNS AND THE VULCANOES.

I SHALL take notice of the ſubterraneous caverns, grottos, and vulcanoes, becauſe they are made an objection [o] againſt the preſent contrivance and ſtructure of the globe. But, if well conſidered, they will be found to be wiſe contrivances of the Creator, ſerving to great uſes of the globe, and ends of God's government. Beſides many ſecret grand functions and operations of nature in the bowels of the earth, that in all probability theſe things may miniſter unto, they are of great uſe to the countries where they are [p]. To inſtance in the very worſt of the

---

[o] 'Nemo dixerit terram pulchriorem eſſe quod cavernoſa 'ſit, quod dehiſcat in multis locis, quod diſrupta caveis et ſpa-'tiis inanibus iiſque nullo ordine diſpoſitis, nulla forma: nec 'quæ aliud contineant quam tenebras et ſordes; unde graves et 'peſtiferæ exhalationes, terræ motus,' etc. Burn. ubi ſup. c. 7.

[p] The Zirchnitzer ſea in Carniola, is of great uſe to the inhabitants of that country by affording them fiſh, fowls, fodder ſeeds,

‘ and wholly delivered from earthquakes by the ‘ breaking forth of a new volcano there: this ‘ continually diſcharging that matter, which being ‘ till then barricaded up, and impriſoned in the ‘ bowels of the earth, was the occaſion of very ‘ great and frequent calamities. Thus far that ingenious author.

CHAP. IV.

OF THE MOUNTAINS AND VALLEYS.

THE laſt thing I ſhall take notice of relating to the earth, ſhall be the Hills and Valleys. Theſe the eloquent theoriſt owns to ‘ contain ſomewhat auguſt and ſtately in the ‘ beholding of them, that inſpireth the mind with ‘ great thoughts and paſſions that we naturally ‘ on ſuch occaſion think of God and his greatneſs. But then, at the ſame time, he ſaith, ‘ The ‘ hills are the greateſt examples of ruin and con‘ fuſion; that they have neither form, nor beauty, ‘ nor ſhape, nor order, any more than the clouds ‘ in the air; that they conſiſt not of any pro‘ portion of parts, referable to any deſign, nor ‘ have the leaſt footſteps of art or counſel.’ Conſequently one grand part of this lower creation, even the whole preſent face of our terraqueous globe, according to this ingenious author, is a work of mere chance, a ſtructure in which the Creator did not concern himſelf.

PART of this charge I have already briefly anſwered, and my ſurvey now leads me to ſhew that the mountains are ſo far from being a blunder of chance, a work without deſign, that they are a noble. uſeful, yea, a neceſſary part of our globe [s]

AND in the firſt place, as to the buſineſs of ornament, beauty, and Pleaſure, I may appeal to all mens ſenſes whether the grateful variety of hills and dales, be not more pleaſing than the largeſt continued planes. Let thoſe who make it there buſineſs to viſit the globe, to divert their ſight with the various proſpects of the earth; let thoſe, I ſay, judge whether the far diſtant parts of the earth would be ſo well worth viſiting, if the earth was every where of an even, level, globous ſurface, or one large plane of many 1000 miles; and not rather, as now it is: whether it be not far more pleaſing to the eye, to view from the tops of the mountains the ſubjacent vales and ſtreams, and the far diſtant hills; and again from the vales to behold the ſurrounding mountains. The elegant ſtrains and lofty flights, both of the ancient and modern poets on theſe occaſions, are teſtimonies of the ſenſe of mankind on this configuration of the earth.

---

[s] 'THOUGH there are ſome that think mountains to be a 'deformity to the earth, &c. yet if well conſidered, they will 'be found as much to conduce to the beauty and conveniency of 'the univerſe, as any of the other parts. Nature (ſaith Pliny) 'purpoſely framed them for many excellent uſes; partly to tame 'the violence of greater rivers, to ſtrengthen certain joints with'in the veins and bowels of the earth, to break the force of the 'ſea's inundation, and for the ſafety of the earth's inhabitants, 'whether beaſts or men. That they make much for the protec'tion of beaſts, the pſalmiſt teſtifies, 'The high hills are a re"fuge for the wild goats, and the rocks for the conies.' The 'kingly prophet had likewiſe learnt the ſafety of thoſe by his 'own experience, when he alſo was fain to make a mountain his 'refuge from the fury of his maſter Saul, who proſecuted him 'in the wilderneſs. True, indeed, ſuch places as theſe keep their 'neighbours poor, as being moſt barren, but yet they preſerve 'them ſafe, as being moſt ſtrong; witneſs our unconquered 'Wales and Scotland.——Wherefore a good author doth rightly 'call them nature's bulwarks, caſt up at God almighty's char'ges, the ſcorns and curbs of victorious armies; which made 'the Barbarians, in Curtius, ſo confident of their own ſafety,' &c. Biſhop Wilkin's World in the Moon, p. 114.

But be the caſe as it will as to beauty, which is the leaſt valuable conſideration, we ſhall find as to convenience, this configuration of the earth is far the moſt commodious on ſeveral accounts.

1. As it is the moſt ſalubrious, of great uſe to the preſervation or reſtoration of the health of man. Some conſtitutions are indeed of ſo happy a ſtrength and ſo confirmed an health as to be indifferent to almoſt any place or temperature of the air: but then others are ſo weakly

and feeble, as not to be able to bear one, but can live comfortably in another place. With ſome, the finer and more ſubtle air of the hills doth beſt agree, who are languiſhing and dying in the feculent and groſſer air of great towns, or even the warmer and vaporous air of the valleys and waters: but contrarywiſe others languiſh on the hills, and grow luſty and ſtrong in the warmer air of the valleys.

So that this opportunity of ſhifting our abode from the warmer and more vaporous air of the valleys, to the colder and more ſubtle air of the hills, or from the hills to the vales, is an admirable eaſement, refreſhment, and great benefit to the valetudinarian, feeble part of mankind, affording thoſe an eaſy and comfortable life, who would otherwiſe live miſerably, languiſh and pine away.

2. To this ſalutary conformation of the earth, we may add another great convenience of the hills, and that is in affording commodious places for habitation: 'Serving (as an eminent author [t] wordeth 'it) as ſkreens to keep of the cold and nipping 'blaſts of the northerly and eaſterly winds, and re'flecting the benign and cheriſhing ſun beams,

---

[t] Ray's Wiſdom of God, etc. p. 251. Diſſolution of the World. p. 35.

‘ and ſo rendering our habitations both more com-‘ fortable and more chearly in winter: and pro-‘ moting the growth of herbs and fruit-trees, and ‘ the maturation of the fruits in ſummer.’

3. Another benefit of the hills is, that they ſerve for the production of great varietys of herbs and trees [u]. And as there was not a better judge of thoſe matters, ſo I cannot give a better account of this convenience, than in the words of the laſt cited famous author, the late moſt eminent and learned Mr. Ray [v] (who hath ſo fully diſcuſſed this ſubject I am upon, that it is ſcarce poſſible to tread out of his ſteps therein.) His obſervation is,‘ That the ‘ mountains do eſpecially abound with different ‘ ſpecies of vegetables, becauſe of the great diver-‘ ſity of ſoils that are found there, every vertex, or ‘ eminence almoſt affording new kinds. Now theſe ‘ plants, ſaith he, ſerve partly for the food and ‘ ſuſtenance of ſuch animals as are proper to the

---

[u] Theophraſtus having reckoned up the trees that delight moſt in the hills, and others in the valleys, obſerveth, Ἅπαντα δὲ ὅσα κοινὰ τῶν ὀρῶν καὶ τῶν πεδίων, μείζω μὲν καὶ καλλίω τῇ ὄψει τὰ ἐν τοῖς πεδίοις γίνεται, κρείττω δὲ τῇτε χρήσει τῶν ξύλων, καὶ τῶν καρπῶν, τὰ ὀρεινά. Theoph. Hiſt. Pl. l. 3. c. 4. Ἅπαντα δὲ ἐν τοῖς οἰκείοις τόποις καλλίω γίνεται, καὶ μᾶλλον εὐσθενεῖ.- -Τὰ μὲν γὰρ φιλεῖ τοὺς ἐφύδρους καὶ ἑλώδεις.---Τὰ δὲ τοὺς εὐσκεπεῖς καὶ εὐηλιεῖς. Ib. l. 4. c. 1.

[v] Wiſdom of God, p. 352.

'mountains, partly for medical uſes; the chief
'phyſic, herbs, and roots, and the beſt in their
'kinds growing there: it being remarkable, that
'the greateſt and moſt luxurious ſpecies in moſt
'genera of plants are natives of the mountains.'

4. Another convenience which my laſt named learned friend obſerves [w] is, 'That the mountains 'ſerve for the harbour, entertainment, and main'tainance of various animals, birds, beaſts, and in'ſects, that breed, feed, and frequent there. For, 'ſaith he, the higheſt tops and pikes of the Alps 'themſelves are not deſtitute of their inhabitants, 'the Ibex or Stein-buck, the Rupicapra or Chamois 'among quadrupeds; the Lagopus among birds. 'And I myſelf, ſaith he, have obſerved beautiful 'Papilios, and ſtore of other inſects upon the tops 'of ſome of the Alpine mountains. Nay the high'eſt ridges of many of theſe mountains ſerve for 'the maintenance of cattle, for the ſervice of the 'inhabitants of the valleys.

5. Another thing he obſerves is, 'That thoſe 'long ridges and chains of lofty and topping moun'tains, which run through whole continents eaſt 'and weſt [x], ſerve to ſtop the evagation of the 'vapours to the north and ſouth in hot countries,

---

[w] Ubi ſupra.

[x] Many have taken notice, that ſome of the greateſt eminencies of the world run generally eaſt and weſt, of which, take the

"condenſing them like alembic-heads into water, 'and ſo (according to his opinion) by a kind of 'external diſtillation giving origin to ſprings and 'rivers; and likewiſe by amaſſing, cooling, and 'conſtipating of them, turn them into rain, by 'thoſe means rendering the fervid regions of the torrid zone habitable.

To theſe might be added ſome other uſes and conveniences[y]; as that the hills ſerve to the generation

late ingenious and learned Dr. Nicho's's account, [Con with a Theiſt, part 2. p. 191.] 'To go no farther than our own country, all 'our great ridges of hills in England run eaſt and weſt; ſo do the 'Alps in Italy, and in ſome meaſure the Pyrenees; ſo do the 'mountains of the moon in Afric, and ſo do mount Taurus and 'Caucaſus. This, he ſaith, is a wiſe contrivance to prevent the 'vapours, which would all run northwards, and leave no rains in 'the Mediterranean countries.

[y] That the generation of many of the clouds is owing to the hills, appears from the obſervations of the ingenious and learned Dr. Joh. Jam. Scheuchzer of Zurich, and Mr. Joach. Frid. Creitlovious cited by him. They obſerved, at ſun-riſing, divers clouds detach'd by the heat of the ſun, from ſome of the tops of the Alps, etc. upon all which their obſervations, the concluſion is, 'Mirati ſummam Creatoris ſapientiam, qui et id quod paulo 'ante nulli nobis uſui eſſe videbatur, maximis rebus deſtinaverat, 'adeoque ex illo tempore dubitare cœpi, num nubes eſſent futuræ, 'ſi iſtiuſmodi montes et petræ non darentur. Hypotheſi hac ſtante, 'eluceſceret permagna utilitas, imo neceſſitas quam Helveticæ 'Alpes non nobis tantum accolis ſed et vicinis aliis regionibus 'præſtant, diſpenſando, quas gignunt nubes, ventos, aquas.' Scheuch. Iter. Alpin. 2. p. 20.

neration of minerals and metals [z], and that in them principally are the moſt uſeful foſſiles found; or if not found and generated only in them, yet at leaſt all theſe ſubterraneous treaſures are moſt eaſily come at in them: alſo their uſe to ſeveral nations of the earth, in being boundaries and bulwarks to them. But there is only one uſe more that I ſhall inſiſt on; and that is.

6. And laſtly, that it is to the hills that the fountains owe their riſe, and the rivers their conveyance. As it is not proper, ſo neither ſhall I here enter into any diſpute about the origin of ſprings, commonly aſſigned by curious and learned philoſophers. But whether their origin be from condenſed vapours, as ſome think [a]; or from rains falling, as others; or whether they are derived from

---

[z] Let us take here Ol. Mag. obſervation of his northern mountains; 'Montes excelſi ſunt, ſed pro majori parte ſteriles, et aridi; 'in quibus fere nil aliud pro incolarum commoditate et conſervatione gignitur, quam inexhauſta pretioſorum metallorum ubertas 'qua ſatis opulenti, fertileſque ſunt in omnibus vitæ neceſſariis, 'forſitan et ſuperfluis aliunde ſi libet conquirendis, unanimique robore, ac viribus, ubi vis contra hæc naturæ dona intentata fuerit, 'defenden dis. Acre enim genus hominum eſt,' etc. Ol. Mag. Hiſt. l. 6. Praef. See alſo Sir Robert Sibbald's Prodr. Nat. Hiſt. Scot. p. 47.

[a] See book I. chap. 3. note d page 33.

the ſea by way of attraction, percolation, or diſtillation or whether all theſe cauſes concur, or only ſome, ſtill the hills are the grand agent in this prodigious benefit to all the earth: thoſe vaſt maſſes and ridges of earth ſerving as ſo many huge alembics or cola in this noble work of nature.

But be the modus, or the method nature takes in this great work as it will, it is ſufficient to my purpoſe, that the hills are a grand agent in this ſo noble and neceſſary a work: and conſequently, that thoſe vaſt maſſes, and lofty piles, are not as they are charged, ſuch rude and uſeleſs excreſcences of our ill-formed globe; but the admirable tools of nature, contrived and ordered by the infinite Creator, to do one of its moſt uſeful works, and to diſpenſe this great bleſſing to all parts of the earth; without which neither animals could live, nor vegetables ſcarcely grow, nor perhaps minerals metals or foſſiles receive any increaſe. For, was the ſurface of the earth even and level, and the middle parts of it iſlands and continents, not mountainous and high, as now it is, it is moſt certain there could be no deſcent for the rivers, no conveyance for the waters: but inſtead of gliding along thoſe gentle declivities which the higher lands now afford them quite down to the ſea, they would ſtagnate, and perhaps ſtink, and alſo drown large tracts of land.

But indeed, without hills, as there could be no rivers, ſo neither could there be any fountains, or ſprings about the earth; becauſe if we could ſuppoſe a land could be well watered, which I think not poſſible, without the higher lands, the waters could find no deſcent, no paſſage through any commodious out-lets, by virtue of their own gravity; and therefore could not break out into thoſe commodious paſſages and currents, which we every where almoſt find in, or near the hills, and ſeldom, or never, in large and ſpacious planes; and when we do find them in them, it is generally at great and inconvenient depths of the earth; nay thoſe very ſubterraneous waters, that are any where met with by digging in theſe planes, are in all probability owing to the hills, either near or far diſtant: as among other inſtances may be made out, from the forcible eruption of the ſubterraneous waters in digging wells, in the Lower Auſtria, and the territories of Modena, and Bologna in Italy, mentioned by my forenamed learned friend Mr. Ray[b]. Or if there be any ſuch place found throughout

---

[b] ‘ Monſieur Blundel related to the Pariſian academy, what de‑
‘ vice the inhabitants of the Lower Auſtria, (which is encompaſſed
‘ with the mountains of Stiria) are wont to uſe to fill their wells
‘ with water. They dig in the earth to the depth of 20 and 25
‘ feet, till they come to an argilla [clammy earth]———which
‘ they bore through ſo deep, till the waters break forcibly out;
‘ which water, it is probable, comes from the neighbouring moun‑
‘ tains in ſubterraneous channels, And caſſinus obſerved, that in many

out the earth, that is devoid of mountains and yet, well watered, as perhaps ſome ſmall iſlands may; yet in this very caſe, that whole maſs of land is no other than as one mountain deſcending, though unperceivedly gently, down from the mid-land parts to the ſea, as moſt other lands do; as is manifeſt from the deſcent of their rivers, the principal of which in moſt countries have generally their riſe in the more lofty mid-land parts.

And now conſidering what hath been ſaid concerning this laſt uſe of the hills, there are two or three acts, concerning of the divine providence, obſervable therein. One is, that all countries throughout the whole world, ſhould enjoy this great benefit of mountains placed here and there, at due and proper diſtances to afford their ſeveral nations this excellent and moſt neceſſary element the waters. For according to natures tendency, when the earth and waters were ſeparated, and ordered to their ſeveral places, the earth muſt have

been

‘ many places of the territory of Modena, and Bologna in Italy, ‘ they make themſelves wells, by the like artifice, &c. By theſe ‘ means the ſame Seig. Caſſina made a fountain at the caſtle of ‘ Urbin, that caſt up the water five foot high above the level of the ‘ ground.’ Ray's Diſc. p. 40 ubi plura.

Upon inquiry of ſome ſkillful workmen, whoſe buſineſs it is to dig wells, &c. whether they had ever met with the like caſe, as theſe in this note; they told me, they had met with it in Eſ-

ſex,

been of an even ſurface, or nearly ſo. The ſeveral component parts of the earth muſt have ſubſided according to their ſeveral ſpecific gravities, and at laſt have ended in a large even, ſpherical ſurface, every where equidiſtant from the centre of the globe. But that inſtead of this form, ſo incommodious for the conveyance of the waters, it ſhould be jetted out every where into hills and dales; ſo neceſſary for that purpoſe, is a manifeſt ſign of an eſpecial providence of the wiſe creator.

So another plain ſign of the ſame eſpecial providence of God, in this matter, is, that generally throughout the whole world, the earth is ſo diſpoſed, ſo ordered, ſo well-laid; I may ſay, that the mid-land parts, or parts fartheſt from the ſea, are commonly the higheſt; which is manifeſt I have ſaid, from the deſcent of the rivers. Now, this is an admirable proviſion the wiſe Creator hath made for the commodious paſſages of the rivers, and for draining the ſeveral countries, and carrying off the ſuperfluous waters from the whole earth, which would be as great an annoyance. as now they are a convenience.

Another providential benefit of the hills ſupplying the earth with water, is, that they are not only inſtrumental

---

ſex, where, after they had dug to 50 feet deep, the man in the well obſerved the clayey bottom to ſwell and begin to ſend out w ter inſtrumental thereby, to the fertility of the valleys, but to their own alſo; [c] to the verdure of the vegetables without, and to the increment and vigour of the treaſures within them.

Thus having vindicated the preſent form and fabric of the earth, as diſtributed into mountains and valleys, and thereby ſhown in ſome meaſure the uſe thereof, particularly of the mountains, which are chiefly found fault with: I have, I hope, made it in ſome meaſure evident, that God was

---

water, and ſtamping with his foot to ſtop the water, he made way for ſo ſudden and forcible a flux of water, that before he could get into his bucket, he was above his waſte in water; which ſoon aſcended to 17 feet high, and there ſtayed: and although they often with great labour, endeavoured to empty the well, in order to finiſh their work, yet they could never do it, but were forced to leave it as it was.

[c] As the hills being higher, are naturally diſpoſed to be dryer than the valleys: ſo kind nature hath provided the greater ſupplies of moiſture for them, ſuch at leaſt of them, as do not aſcend above the clouds and vapours. For, beſides the fountains, continually watering them, they have more dews and rain commonly than the valleys. They are more frequently covered with fogs; and by retarding, ſtopping, or compreſſing the clouds, or by their greater colds condenſing them, they have larger quantities of rain fall upon them: as I have found by actual experience, in comparing my obſervations with thoſe of my late very curious and ingenious correſpondent, Richard Townley Eſq. of Lancaſhire, and ſome others to be met with before, book I. chap. 2 From which it appears, that above double the quantity of rain falleth in Lancaſhire, that doth at Upminſter: the reaſon of which is

was no idle ſpectator, [d] nor unconcerned in the ordering of the terraqueous globe, as the former bold charges againſt it do infer; that he did not ſuffer ſo grand a work, as the earth, to go unfiniſhed out of his almighty hand; or leave it to be ordered by chance, by natural gravity, by caſual earthquakes, &c: but that the noble ſtrokes, and plain remains of wiſdom, and power therein, do manifeſt it to be his work. That particularly the hills and vales, though to a peeviſh weary traveller, they may ſeem incommodious and troubleſome; yet, are a noble work of the great Creator, and wiſely appointed by him for the good of our ſubluminary world.

AND ſo for all the other parts of the terraqueous globe, that are preſumed to be found fault with by ſome, as if careleſsly ordered, and made without any deſign or end: particularly the diſtribution of the dry land and waters; the laying the ſeveral ſtrata, or beds of earth, ſtone and other layers before ſpoken of; the creation of noxious animals, and poiſonous ſubſtances, the boiſterous winds; the vulcanos, and many other things which ſome are

---

is, becauſe Lancaſhire hath more and much higher hills than Eſſex hath. See book II. chap. 5.

[d] ‘ ACCUSANDI ſane mea ſententia hic ſunt ſophiſtæ, qui ‘ cum nondum invenire, neque exponere opera naturæ queant, ‘ eam

are angry with, and will pretend to amend: I have before ſhewn that an infinitely wiſe providence, an almighty hand was concerned even in them; that they all have their admirable ends and uſes, and are highly inſtrumental and beneficial to the being, or well-being of this our globe, or to the creatures reſiding thereon.

So alſo for human bodies, it hath been an antient [e] as well as modern complaint, that our bodies are not ſo big as thoſe of other animals; that we cannot run as ſwift as deer, fly like birds, and that we are out-done by many creatures in the accuracy of the ſenſes, with more to the ſame purpoſe. But theſe objections are well anſwered by Seneca

---

' eam tamen inertiæ atque inſcitiæ condemnant,' etc. Galen de Uſ. Part. l. 10. c. 9.

[e] ' Vide quam iniqui ſint divinorum munerum æſtimatores,
' etiam quidam profeſſi ſapientiam. Queruntur quod non magnitudine
' corporis æquemus elephantes. velocitate cervos levitate
' aves impetu tauros; quod ſolidior ſit cutis belluis, decentior
' damis, denſior urſis, mollior fibris: quod ſagacitate nos narium
' canes vincant, quod acie luminum aquilæ, ſpatio ætatis corvi
' multa animalia nandi facilitate. Et cum quædam ne coire quidem
' in idem natura patiatur, ut velocitatem, corporis et vires
' pares anamalibus habeamus; ex diverſis et diſſidentibus bonis
' hominem non eſſe compoſitum, injuriam vocant, et innegligentes
' noſtri deos querimonim jaciunt, quod non bona valetudo,
' et vitiis inexpugnabilis data ſit, quod non futuri ſcientia.
' vix ſibi temperant quin euſque impudentiæ provehantur, ut
' naturam

Seneca [f], and will receive a fuller ſolution from what I ſhall obſerve of animal bodies hereafter.

But indeed, after all, it is only for want of our knowing theſe things better, that we do not admire [g] them enough; it is our own ignorance, dulneſs, or prejudice, that makes us charge thoſe noble works of the Almighty, as defects or blunders, as ill contrived, or ill made.

It is therefore fitter for ſuch finite, weak, ignorant beings as we, to be humble and meek, and conſcious of our ignorance, and jealous of our own judgement, when it thus confronteth infinite wiſdom. Let us remember how few things we know, how many we err about, and how many we

---

' naturam oderint, quod infra deos ſumus, quod non in æquo illis ſtetimus.' Seneca, de Benef. l. 2. c. 29.

[f] ' Quanto ſatius eſt ad contemplationem tot tantorumque ' beneficiorum reverti, et agere gratias, quod nos in hoc pulcherrimo ' domicilio voluerunt [dii] ſecundos ſortiri, quod terrenis ' præfecerunt.' Then having reckoned up many of the privileges and benefits, which the gods, he ſaith, have conferred upon us, he concludes.' Ita eſt: cariſſimos nos habuerunt dii immor' tales, habentque. Et qui maximus tribui honos potuit, ab ipſis ' proximos collocaverunt. Magna accepimus majora non cepi' mus.' Senec. ibid.

[g] ' Naturam maxime admiraberis, ſi omnia ejus opera perluſ' traris.' Galen. de Uſ. Part l. 11. conclu.

are ignorant of: and thoſe many of them the moſt familiar, obvious things: things that we ſee and handle at pleaſure; yea, our own very bodies and that very part of us whereby we underſtand at all, our ſoul. And ſhould we therefore pretend to cenſure what God doth! Should we pretend to amend his work! Or to adviſe infinite wiſdom! Or to know the ends and purpoſes of his infinite will, as if we were of his council! No, let us bear in mind, that theſe objections are the products not of reaſon, but of peeviſhneſs. They have been incommoded by ſtorms and tempeſts; they have been terrified with the burning mountains, and earthquakes; they have been annoyed by the noxious animals, and fatigued by the hills; and therefore are angry and will pretend to amend theſe works of the Almighty. But in the words of St. Paul[h], we may ſay, 'Nay, but O man, what art 'thou that replieſt againſt God? Shall the thing 'formed, ſay to him that formed it, why haſt 'thou made me thus? Hath not the potter power 'over the clay, of the ſame lump, to make one 'veſſel to honour, and another to diſhonour?' If the Almighty Lord of the earth, had for his own pleaſure, made this our world, more inconvenient for man, it would better become us to ſit ſtill, and be quiet; to lament our own great infirmities and failings, which deſerve a worſe place, a more incommodious habitation, than we meet with in this elegant, this well contrived, well formed world; in which we find every thing neceſſary for the ſuſtentation, uſe and pleaſure, both of man, and every other creature here below; as well as ſome whips, ſome rods to ſcourge us for our ſins [i]. But yet ſo admirably well tempered is our ſtate, ſuch an accord, ſuch an harmony is there throughout the creation, that if we will but purſue the ways of piety and virtue, which God hath appointed; if we will form our lives according to the Creator's laws, we may eſcape the evils of this our frail ſtate, and find ſufficient means to make us happy, whilſt we are in the body. The natural force and tendency of

---

[h] Rom. ix. 20, 21.

---

[i] 'NEITHER are they [noxious creatures] of leſs uſe to amend 'our minds, by teaching us care and diligence, and more wit. 'And ſo much the more, the worſe the things are we ſee, and 'ſhould avoid. Weaſels, kites, and other miſchievious animals, 'induce us to a watchfulneſs: thiſtles and moles to good huſbandry: lice oblige us to cleanlineſs in our bodies; ſpiders in our 'houſes; and the moth in our cloaths. The deformity and 'filthineſs of ſwine, make them the beauty-ſpot of the animal creation, and the emblems of all vice.——The truth is, things are 'hurtful to us only by accident; that is not of neceſſity, but 'but through our own negligence or miſtake. Houſes decay, 'corn is blaſted, and the weaſel breeds in malt, ſooneſt toward the 'ſouth, Be it ſo, it is then our own fault, if we uſe not the means which nature and art hath provided againſt theſe inconveniences.' Grew's Coſmol. ch. 2, ſect. 49, 50.

'No

of our virtue, will prevent many of the harms [k], and the watchful providence of our almighty benefactor, will be a guard againſt others; and then nothing is wanted to make us happy, as long as we are in this world, there being abundantly enough to entertain the minds of the moſt contemplative; glories enough to pleaſe the eye of the moſt curious and inquiſitive; harmonies and concerts of nature's own, as well as man's making, ſufficient to delight the ear of the moſt harmonious and muſical; all ſorts of pleaſant guſtos to gratify the taſte and appetite, even of the moſt luxurious; and fragrant odours to pleaſe the niceſt and tendereſt ſmell; and in a word, enough to make us love and delight in the world, rather too much than too little, conſidering how nearly we are allied to another world, as well as this.

---

[k] NON eſt gemendus, nec gravi urgendus nece,
Virtute quiſquis abſtulit fatis iter.
Senec. Hercul. Oet. Act. 5, Car. 1833.

NUNQUAM Stygias fertur ad umbras
Inclyta virtus. Id. Ibid. Car. 198.

BOOK IV.

OF ANIMALS IN GENERAL.

IN the laſt book, having ſurveyed the earth itſelf in particular, I ſhall next take a view of the inhabitants thereof; or the ſeveral kinds of creatures [1], that have their habitation growth or ſubſiſtence thereon.

THESE creatures are either ſenſitive, or inſenſitive creatures.

IN ſpeaking of thoſe endowed with ſenſe, I ſhall conſider.

I. SOME

---

[1] PRINCIPIO cœlum ac terras, compoſque liquentes.
Lucentemque globum lunæ, Titaniaque aſtra
Spiritus intus alit, totamque infuſa per artus
Mens agitat molem, et magno ſe corpore miſcet.

Inde

I. SOME things common to them all.

II. THINGS peculiar to their tribes.

I. THE things in common, which I intend to take notice of are theſe ten.

1. THE five ſenſes, and their organs.

2. THE great inſtrument of vitality, reſpiration.

3. THE motion, or loco-motive faculty of animals.

4. THE place in which they live and act.

5. THE balance of their numbers.

6. THEIR food.

7. THEIR cloathing.

8. THEIR houſes, neſts, or habitations.

9. THEIR methods of ſelf preſervation.

10. THEIR generation and conſervation of their ſpecies by that means.

> Inde hominum, pecudumque genus, vitæque volantum,
> Et quæ marmoreo fert monſtra ſub æquore pontus,
> Igneus eſt illis vigor, et cœleſtis origo
> Seminibus. Virg. Æn. L. 6. Carm. 724.

CHAP I.

OF THE FIVE SENSES IN GENERAL.

THE firſt thing to be conſidered, in common to all the ſenſitive creatures, is, their faculty of ſeeing, hearing, ſmelling, taſting, and feeling; and the organs miniſtering to theſe five ſenſes, together with the exact accommodation of thoſe ſenſes, and their organs, to the ſtate and make of every tribe of animals [m]. The conſideration of which particulars alone, were there no other demonſtrations of God, is abundantly ſufficient to evince the infinite wiſdom, power and goodneſs, of the great Creator. For, who can but ſtand amazed at the glories of theſe works! at the admirable artifice of them! and at their noble uſe and performances! For, ſuppoſe an animal, as ſuch, had breath and life, and could move itſelf hither and thither; yet how could it know whither to go, what it was about, where to find its food, how to avoid thouſands of dangers[n], without ſight! How could man, particularly, view the glories of the heavens, ſurvey the beauties of the fields, and enjoy the pleaſure of beholding the noble variety of diverting objects, that do, above us in the heavens, and here in this lower world, preſent themſelves to our view every where; how enjoy this, I ſay, without that admirable ſenſe of ſight[o]! How could alſo the animal, without ſmell and taſte, diſtinguiſh its food, and diſcern between wholſome and unwholſome; beſides the pleaſures of delightful odours, and reliſhing guſtos! How, without that other ſenſe of hearing, could it diſcern many dangers that are at a diſtance, underſtand the mind of others, perceive the harmonious ſounds of muſic, and be delighted with the melodies of the winged choir, and all the reſt of harmonies the Creator hath provided for the delight and pleaſure of his creatures! And laſtly, how could man, or any other creature, diſtinguiſh pleaſure from pain, health from ſickneſs, and conſequently be able to keep their body ſound and entire, without the ſenſe of feeling! Here, therefore, we have a glorious œconomy in every animal, that commandeth admiration, and deſerveth our contemplation: as will better appear by coming to particulars, and diſtinctly conſidering the proviſion which the Creator hath made for each of theſe ſenſes.

---

[m] 'Ex ſenſibus ante cætera homini tactus, deinde guſtatus: reliquis ſuperatur a multis. Aquilæ clarius cernunt: 'vultures ſagacius odorantur, liquidius audiunt talpæ obrutæ 'terra tam denſo atque ſurdo naturæ elemento.' Plin. Nat Hiſt. L. 10. c 69.

---

[n] ‘ SUBJACENT oculi, pars corporis pretioſiſſima, et qui lucis uſu vitam diſtinguunt a morte. Plin. Nat. Hiſt. l. 11. c. 37.

[o] ‘ Foeminæ aliquæ Megarenſes ſolis oculis diſcernere valebant inter ova quæ ex gallina nigra, et quæ ex alba nata ſunt, is what is affirmed. how truly I know not, by Grimald. de Lumin. et Color. Pr. 43. Sect. 60.

CHAP. II.

OF THE EYE.

FOR our clearer proceeding in the conſideration of this noble part [p], and underſtanding its œconomy, I ſhall conſider,

1. THE form of the eye.

2. ITS ſituation in the body.

3. ITS motions.

4. ITS

---

[p] 'In diſſectionibus anatomicis vix aliquid admirabilius, 'aut artificioſius ſtructura oculi humani, meo quidem judicio, 'occurrit: ut merito, per excellentiam, Creatoris appelletur 'miraculum.' Gul. Fabr. Hildan. Cent. 2. obſerv. 1.

So likewiſe that accurate ſurveyor of the eye, Dr. Briggs, whoſe Opthalmography I have met with ſince my penning this part

4. Its ſize.

5. Its number.

6. Its parts.

7. The guard and ſecurity nature hath provided for this ſo uſeful a part.

As this eminent part hath not been pretermitted by authors, that have made it their particular deſign and buſineſs to ſpeak of the works of God; ſo divers of the aforeſaid particulars have been touched upon by them. And therefore I ſhall take in as little as poſſible of what they have ſaid; and as near as I can, mention chiefly what they have omitted. And,

1. For the form of the eye; which is for the moſt part globulus, or ſomewhat of the ſpheroidal

---

part of my ſurvey. His character of this curious piece of God's work is, 'Inter præcipuas corporis animati partes, quæ magni 'conditoris noſtri ſapientiam oſtendunt, nulla ſane reperitur, 'quæ majori pompa elucet quam ipſe oculus, aut quæ elegantiori forma, concinnatur. Dum enim aliæ partes vel minori 'ſatellitio ſtipantur, vel in tantam venuſtatem haud aſſurgunt; 'ocelli peculiarem honorem et decus a ſupremo numine efflatum 'referunt, et nunquam non ſtupendæ ſuæ potentiæ characteres 'repræſentant. Nulla ſane pars tam divino artificio et ordine,' &c. cap. 1. ſect. 1.

roidal form, which is far the more commodious optical form, as being fitteſt to contain the humours within, and to receive the images of objects from without [g]. Was it a cube, or of any multangular form, ſome of its parts would lie too far off [r], and ſome too nigh thoſe lenticular humours, which by their refractions cauſe viſion. But by means of the form before- mentioned, the humours of the eye are commodiouſly laid together, to perform their office of refraction; and the retina, and every other part of that little darkened cell, is neatly adapted regularly to receive the images from without, and to convey them accordingly to the common ſenſory in the brain.

---

[g] IT is a good reaſon, friar Bacon aſſigns for the ſphæricity of the eye: Nam ſi eſſet planæ figuræ, ſpecies rei majoris oculo non poſſet cadere perpendiculariter ſuper eum—— 'Cum ergo oculus videt magna corpora, ut fere quartam coeli 'uno aſpectu, manifeſtum eſt, quod non poteſt eſſe planæ figuræ 'nec alicujus niſi ſphæricæ, quoniam ſuper ſphæram parvam 'poſſunt cadere perpendiculares infinitæ, quæ a magno corpore 'veniunt, et tendunt in centrum ſphæræ: et ſic magnum corpus 'poteſt ab oculo parvo videri.' For the demonſtration of which he hath given us a figure. Rog. Bacon. Perſpect. Hiſt. 4. cap. 4.

DR. Briggs ſaith, 'Pars antica, [ſive cornea] convexior eſt poſtica, hac enim ratione radii melius in Pupillam detorquentur, 'et oculi fundus ex altera parte in majorem (propter imagines 'rerum ibidem delineandos) expanditur.' Ibid. ſect. 2.

[r] SUPPOSE the eye had the retina, or back part, flat for the reception of the images, as in Fig. 1. A B A; it is manifeſt that if the extremes of the image A A were at a due focal diſtance, the

To this we may add the aptitude of this figure to the motion of the eye; for as it is neceſſary for the eye to move this way, and that way, in order to adjuſt itſelf to the objects it would view; ſo by this figure it is well prepared, for ſuch motions, ſo that it can with great facility and dexterity direct itſelf as occaſion requires.

And as the figure, ſo no leſs commodious is

2. The ſituation of the eye; namely, in the head [s], the moſt erect, eminent part of the body, near the moſt ſenſible vital part, the brain. By its eminence in the body, it is prepared to take-in the

---

the middle B would too be nigh the cryſtalline, and conſequently appear confuſed and dim; but all parts of the retina lying at a due focal diſtance from the cryſtalline, as at A C A, therefore the image painted thereon is ſeen diſtinct and clear. Thus in a dark room, with a lens at a hole in the window, (which Sturmius calls his artificial eye, in his Exercit. And one of which he had made for his pupils, to run any where on wheels): in this room, I ſay, if the paper that receives the images be too nigh, or too far off the lens, the image will be confuſed and dim? but in the focus of the glaſs, diſtinct, clear, and a pleaſant ſight.

[s] 'Blemmyis traduntur capita abeſſe, ore et oculis pectore 'affixis.' Plin. Nat. Hiſt. l. 5. c. 8. 'Occidentem verſus quoſdam

the more objects [t], And by its ſituation in the head; beſides its proximity to the brain, it is in the moſt convenient place for defence and ſecurity; in the hands, it might indeed (in man) be rendered more eminent than the head; and be turned about here and there at pleaſure: but then it would be expoſed to many injuries in that active part, and the hands [u] rendered a leſs active and uſeful part. And the like may be ſaid to its ſcite in any other part of the body, but where it is. But in the head, both of man, and other animals, it is placed in a part that ſeems to be contrived and made, chiefly for the action of the principal ſenſes.

ANOTHER thing obſervable in the ſight of the eye, is the manner of its ſituation in the head, in the forepart or ſide-part thereof, according

---

‘ quoſdam ſine cervice oculos in humeris habentes. Ib. l. 7. c. 2. From theſe, and other ſuch like fables, in this laſt cited chapter of Pliny, no doubt our famous romancer Sir J. Mandeville had his romantic ſtories related in his travels.

[t] SEE book v. chap. 2.

[u] GALEN deſerves to be here conſulted, who in his book De Uſu Partium, from many conſiderations of the hand, ſuch as what is here mentioned, as alſo its ſtructure, ſite, and uſe largely proves and reflects upon the wiſdom and providence of the contriver and maker of that part.

to the particular occaſions of particular animals. In man, and ſome other creatures, it is placed to look directly forward chiefly; but withal it is ſo ordered, as to take in near the miſphere before it. In birds, and ſome other creatures, the eyes are ſo ſeated, as to take in near a whole ſphere, that they may the better ſeek their food and eſcape dangers. And in ſome creatures, they are ſeated ſo as to ſee beſt behind them [v] or on each ſide, whereby they are enabled to ſee their enemy that purſues them that way, and ſo make their eſcape.

AND for the aſſiſtance of the eyes, and ſome of the other ſenſes in their actions, the head is generally made to turn here and there, and move as occaſion requires. Which leads me to

THE third thing to be remarked upon, the motions of the eye itſelf. And this is generally upwards, downwards, backwards forwards, and every way [w], for the better, more eaſy, and diſtinct reception of the viſual rays.

---

[v] Thus in hares and conies, their eyes are very protuberant and placed ſo much towards the ſides of their heads, that their two eyes take in nearly a whole ſphere: whereas in dogs, that purſue them the eyes are ſet more forward in the head, to look that way more than backward.

[w] ‘SED lubricos oculos fecit [Natura] et mobiles, ut et declinarent ſiquid noceret; et aſpectum, quo vellent, facile con‘verterent.’ Cic. de Nat. Deor. l. 2. c. 57.

BUT where nature any way deviateth from this method, either by denying motion to the eyes or the head [x], it is a very wonderful proviſion ſhe hath made in the caſe. Thus for a remedy of

---

[x] ‘ The eyes of ſpiders, (in ſome four, in ſome ſix, and ‘ in ſome eight) are placed all in the fore-front of their head, ‘ (which is round, and without any neck) all diaphanous and ‘ tranſparent, like a locket of diamonds, &c. neither wonder ‘ why providence ſhould be ſo anomalous in this animal, more ‘ than in any other we know of, For, 1. Since they want‘ing a neck, cannot move their head, it is requiſite that defect ‘ ſhould be ſupplied by the multiplicity of eyes. 2. Since they ‘ were to live by catching ſo nimble a prey as a fly is, they ‘ ought to ſee her every way, and to take her per ſaltum, as they ‘ do, without any motion of the head to diſcover her: which ‘ motion would have ſcared away ſo timorous an inſect.’ Power's Microſ. Obſerv. p. 11.

‘ THE eyes of the cameleon reſemble a lens, or convex glaſs, ‘ ſet in a verſatile globular ſocket, which ſhe turneth backward ‘ or any way, without moving her head; and ordinarily the ‘ one a contrary, or quite different way from the other.’ Dr. Goddard in Phil. Tranſ. N° 137.

‘ BUT what is more extraordinary in this motion [of the Came‘leon's eye] is to ſee one of the eyes move, whilſt the other re‘mains immoveable; and the one to turn forward, at the ſame ‘ time that the other looketh behind; the one to look up to the ‘ ſky, when the other is fixed on the ground. And theſe motions ‘ to be ſo extreme, that they do carry the pupilla under the creſt ‘ which makes the eye-brow, and ſo far into the canthi, or cor‘ners of the eyes, that the ſight can diſcern whatever is done ‘ juſt behind it, and directly before, without turning the head, ‘ which is faſtened to the ſhoulder. Mem. for a Nat. Hiſt. in Anat. Diſſ.tParis,Diſſ.C of Camel. p. 22.

this inconvenience, in ſome creatures their eyes are ſet out at a diſtance from the head , to be circumvolved here and there; or, one this, the other that way at pleaſure. And in creatures, whoſe eyes are without motion, as in divers inſects; in this caſe, either they have more than two eyes, or their eyes are nearly two protuberant hemiſpheres, and each hemiſphere often conſiſting of a prodigious number of other little ſegments of a ſphere[z]. By which means thoſe creatures are ſo far from being denied any benefit of that noble and moſt neceſſary ſenſe of ſight that they have probably more of it than other creatures, anſwerable to the rapidity of their flight, and briſk motion; and to their inqueſts after food, habitation, or repoſitories of generation, or ſuch other neceſſity of the animal.

4. ANOTHER admirable proviſion in the eye is, its ſize; in ſome animals large, in ſome

---

[y] SNAILS ſend out their eyes at a diſtance, they being contained in their four horns, 'like atramentous ſpots, fitted to 'the ends of their horns, or rather to the ends of thoſe black 'filaments or optic nerves, which are ſheathed in their horns,' as Dr. Power wordeth it, Obſ. 31 p 36. So the ingenious Dr. Liſter, Exercit. Anat. Cochl. et Limac.

[z] VID. l 8.c. 3 note (*h*), page 369.

little. It would be endleſs here to enumerate particulars; as thoſe of quadrupeds, birds, inſects, and other terreſtrial animals. And as for fiſhes, they will fall under another part of my ſurvey.

I SHALL therefore only take notice of its ſize in one creature, the mole [a]. As the habitation

---

[a] Severinus is of Ariſtotles, Pliny's, and Alb. Magnus's opinion, that the mole hath no ſight; G. Seger denies any humour to be therein, but thinks they may probably ſee, becauſe nature made nothing in vain. But Borrichius ſaith, their eyes have 'appendiculam nerveam in cerebrum euntem, cujus beneficio globuli illi [the little eyes] extra pellem facile poterant exſeri, retrahique pro arbitrio——In illis oculorum globulis humor aqueus copioſe ſatis natabat; cæterorum non niſi tenue veſtigium.' Blaſ. Anat. Anim. c. 35.

'ET quoniam natura hoc vitæ genus ipſi deſtinavit, etiam perquam exiguos oculos dedit eo conſilio, ut ii, pretioſiſſima corporis pars, a terræ pulvere ne affligerentur. Ii inſuper pilis tecti, &c. Humores illis oculis inſunt, et tunica nigra, uvea ſe prodit. Ad hos tramite alio nervus venit.' Schneider in Blaſ. ibid.

SOME time ſince I made divers accurate diſſections of the eyes of Moles, with the help of microſcopes, having a doubt whether what we take to be eyes, were ſuch or no. And upon a ſtrict ſcrutiny I plainly could diſtinguiſh the vitreous and cryſtalline humours, yea, the ligamentum ciliare, and the atramentaceous Mucus. The pupil I could manifeſtly diſcern to be round, and the cornea copped, or conical: the eye is at a great diſtance from the brain, the optic nerve very ſlender and of that uncouth animal is wholly ſubterraneous, its lodging, its food, its exerciſes, nay, even all its paſtimes and pleaſures, are in thoſe ſubterraneous receſſes and paſſages, which its own induſtry hath made for itſelf; ſo it is an admirable proviſion made in the ſize of the eye of that little creature, to anſwer all its occaſions, and, at the ſame time, to prevent inconveniences. For, as a little light will ſuffice an animal living always under ground; ſo the ſmalleſt eye will abundantly ſupply that occaſion. And as a large protuberant eye, like that of other animals, would much annoy this creature in its principle buſineſs, of digging for its food and paſſage; ſo it is endued with a very ſmall one commodiouſly ſeated in the head, and well fenced and guarded againſt the annoyances of the earth

---

long, reaching from the eye through the intermediate fleſh, and ſo paſſeth to the brain, along with the pair of nerves reaching to the noſe, which are much the largeſt that are in all the animal. Theſe creatures, I imagine, have the faculty of withdrawing their eyes, if not quite into the head, as ſnails, yet more or leſs within the hair, as they have more or leſs occaſion to uſe or guard their eyes.

GALEN ſaith, moles have eyes, the cryſtalline and vitreous humours, encompaſſed with tunics. De Uſ. Part. l. 14. c. 6. So accurate an anatomiſt was he for his time.

5. ANOTHER thing remarkable in this noble part of animals, is, its number; no leſs than two [b], in any inſtance that I know of; and in ſome animals, more, as I have already hinted [c].

Now, this is an admirable proviſion; firſt, for the convenience of taking in the larger angle, or ſpace: and in the next place, the animal is by this proviſion, in ſome meaſure, prepared for the misfortune of the loſs of one of theſe noble, and neceſſary organs of its body.

BUT then beſides all this, there is another thing conſiderable in this multiplicate number of the eye; and that is, that the object, ſeen is not multiplied as well as the organ, and appears but one, though ſeen with two or more eyes [d]. A manifeſt

---

[b] PLINY tells us, of a ſort of heron with but one eye, but it was only by hear-ſay. 'Inter aves ardeolarum genera, quos 'leucos vocant, altero oculo carere tradunt.' Nat. Hiſt. l. 11 c. 37. So the king of the Nigræ that hath but one eye, and that in his forehead. l. 6. c. 30. Which fables I take notice of more for the reader's diverſion, than any truth in them.

[c] SUPRA, note (*x*) page 127,

[d] THE moſt celebrated anatomiſts differ greatly about the reaſon, why we ſee not double with two eyes. This Galen, and others after him, generally thought to be from a coalition or decuſſation of the optic nerves, behind the os ſphenoides. But

manifeſt ſign of the infinite ſkill of the contriver of this ſo noble a part, and of the exquiſite art he employed in the formation thereof. But the deſign and ſkill of the infinite workman will beſt be ſet forth by,

6. SUR-

But whether they decuſſate, coaleſce, or only touch one another, they do not well agree. The Bartholines expreſly aſſert they are united, 'Non per ſimplicem contactum vel interſectionem in homine, ſed totalem ſubantiæ confuſionem.' Anat. l. 3. c. 2. And whereas Veſalius, and ſome others, had found ſome inſtances of their being diſunited; they ſay, 'Sed in pleriſque ordinarie confunditur interior ſubſtantiæ, ut accurata diſquiſitione deprehendi.

BUT our learned Dr. Gibſon (Anat. l: 3. c. 10.) ſaith, they 'are united by the cloſeſt conjunction, but not confuſion of their 'fibres.'

BUT others think the reaſon is not from any coaleſcence contact, or croſſing of the optic nerves, but from a ſympathy between them. Thus monſieur Cartes is of opinion, that the fibrillæ, conſtituting the medullary part of thoſe nerves, being ſpread in the retina of each eye, have each of them correſponding parts in the brain; ſo that when any of thoſe fibrillæ are ſtruck by any part of an image, the correſponding part of the brain are thereby affected, and the ſoul thereby informed, &c. But ſee more hereafter under note (*b*), page 148. *from* Cartes himſelf.

SOMEWHAT like this is the notion of our judicious Dr. Briggs, who thinks the optic nerves of each eye, conſiſt of homologous fibres, having their riſe in the thalamus nervorum opticorum, and thence continued to both the retinæ, which are made of them

6. SURVEYING the parts and mechaniſm of this admirable organ, the eye. And here indeed

---

them: and farther, that thoſe fibrillæ have the ſame parallelíſm, tenſion, etc. in both eyes; and conſequently, when an image is painted on the ſame correſponding, ſympathizing parts of each retina, the ſame effects are produced, the ſame notice or information is carried to the thalamus, and ſo imparted to the ſoul, or judging faculty. That there is ſuch an ’Ομοιοπάθεια between the retina, &c. he makes very probable, from the enſuing of double viſion upon the interruption of the parallelíſm of the eyes; as when one eye is depreſſed with the finger, or their ſymphony interrupted by diſeaſe, drunkenneſs, &c. And laſtly, that ſimple viſion is not made in the former way, viz. by a decuſſation or conjunction of the optic nerves, he proves, becauſe thoſe nerves; but in few ſubjects decuſſated, and in none conjoined otherwiſe than by a bare contact, which is particularly manifeſt in fiſhes; and in ſome inſtances it hath been found, that they have been ſeparated without any double viſion enſuing thereupon. Vide Brig. Ophthalmog. cap. 11. and 5. and Nov. Viſ. Theor. paſſim.

WHAT the opinion of our juſtly eminent Sir Iſaac Newton is may be ſeen in his Optics, Qu. 15. ‘ Are not the ſpecies of ‘ objects ſeen with both eyes, united where the optic nerves ‘ meet before they come into the brain, the fibres on the right ‘ ſide of both nerves uniting there? &c. For the optic nerves ‘ of ſuch animals as look the ſame way with both eyes, (as of ‘ men, dogs, ſheep, oxen, &c.) meet before they come into ‘ the brain: but the optic nerves of ſuch animals as do not ‘ look the ſame way with both eyes, (as of fiſhes, and of the ‘ cameleon) do not meet, if I am rightly informed.’ Newt. Opt. Qu. 15.

we cannot but ſtand amazed, when we view its admirable fabric, and conſider the prodigious exactneſs, and the exquiſite ſkill employed in every part miniſtering to this noble and neceſſary ſenſe. To paſs by its arteries and veins, and ſuch other parts common to the reſt of the body, let us caſt our eye on its muſcles. Theſe we ſhall find exactly and neatly placed for every motion of the eye. Let, us view its tunics, and theſe we ſhall find ſo admirably ſeated, ſo well adapted, and of ſo firm a texture, as to fit every place, to anſwer every occaſion, and to be proof againſt all common inconveniences and annoyances. Let us examine its three humours and theſe we ſhall find all of exquiſite clearneſs and tranſparency, for an eaſy admiſſion of the rays: well placed for the refracting of them, and formed, particularly the cryſtalline humour, by the niceſt laws of optics, to collect the wandring rays into a point. And, to name no more, let us look into its darkened cell, where thoſe curious humours lie, and into which the glories of the heavens and the earth are brought, and exquiſitely pictured; and this cell we ſhall find, without, well prepared by means of its texture, aperture, and colour, to fence off all the uſeleſs or noxious rays; and within, as well coated with a dark tegument, that it may not reflect, diſſipate, or any way confuſe or diſturb the beneficial rays [e].

BUT to deſcend to particulars, although it would be a great demonſtration of the glory of God, yet would take up too much time, and hath been, in ſome meaſure, done by others that have written of God's works. Paſſing over therefore what they have obſerved, I ſhall, under each principal part, take a tranſient notice of ſome things they have omitted, or but ſlightly ſpoken of.

AND my firſt remark ſhall be concerning the muſcles of the eye, and their equilibration. Nothing can be more manifeſtly an act of contrivance and deſign, than the muſcles of the eye, admirably adapted to move it any, and every way; upwards, downwards, to this ſide or that, or howſoever, we pleaſe, or there is occaſion for, ſo as to always keep that parrallelism of the eye, which is neceſſary to true viſion. For the performance of which ſervice, the form, the poſition, and the due ſtrength of each muſcle, is admirable. And here I might inſtance the peculiar and artificial ſtructure of the trochlearis, and the augmentation of its power by the trochlea [f]; the magnitude and ſtrength of the attollent muſcle, ſomewhat exceeding that of its antagoniſt; the peculiar muſcle, called the ſeventh, or ſuſpenſory muſcle, [g], given to brutes, by reaſon of the

---

[e] 'Nigra eſt [uvea] ut radios, ab oculi fundo ad anteriorem ejus partem reflexos, obumbret; ne hi, ut ait clar. Carteſius, ad oculi fundum retorti ibidem confuſam viſionem efficerent. Alia forſan ratio hujus nigredinis ſtatuatur, quod radii in viſione ſuperflui, qui ab objectis lateralibus proveniunt hoc ritu abſorbeantur. Ita enim e loco obſcuro interdiu objecta optime intuemur, quia radii tunc temporis circumfuſo lumine non diluuntur.' Brigg's Ophthal. cap. 3. ſect. 5.

---

[f] 'Admirandum Dei artificium ex diverſorum animalium, 'comparatione indies evadit manifeſtius. Mirantur omnes trochlearem in oculis hominum et quadrupedum, et quidem jure: ſed, 'admirationem omnem ſuperat, quod ſine trochlea oculum movens in avibus novum genus trochleæ longe artificioſius nictitandi membranæ dederit.' Blaſ. An. Ani. p. 2. c. 4 ex Stenon.'

[MUSCULUM Trochlearem] 'per intermediam trochleam traductum, nunquam intueor, quin admirabundus mecum, 'Ο Θεός, *exclamem*, οὐ μόνον ἀεί γεωμετρεῖ, ἀλλά και ἀεί μηχανᾶται.' I. C. Sturmii Exer. Aca. 9. de Viſ. Org. et Rat. c. 3. ſect. 4. p. 446

[g] OBSERVARE eſt quod quadrupedes qui oculos in terram 'pronos, ac pendulos gerunt, muſculum peculiarem habent, quo 'oculi globus ſuſpenditur——Hoc muſculo, bos equus, ovis, lepus, porcus, &c. præditi ſunt: hoc etiam canis inſtruitur, ſed 'alio modo conformatum habet.' Wil. de Brut. An. p. 1. c. 15.

OF this opinion alſo was Bartholine, Anat. l. 3. c. 8. and divers other eminent anatomiſts.

BUT

the prone poſture of their bodies, and frequent occaſions to hang down their heads: and I might ſpeak alſo of the peculiar origin and inſertion of the lower oblique muſcle [h], which is very notable, and many other things relating to theſe parts; but it would be tedious to deſcend too much to thoſe admirable particulars. And therefore to cloſe up theſe remarks, all I ſhall farther take notice of, ſhall be only the exquiſite equilibration of all theſe oppoſite and antagoniſt muſcles, affected partly by the equality of the ſtrength; which is the caſe of the adducent and abdu-

---

BUT Dr. Briggs is of opinion that the adnata, and the other muſcles ſufficiently anſwer all thoſe ends aſcribed to that muſcle by former anatomiſts, and thinks 'probabilius itaque eſſe hunc 'muſculum nervi optici actionem, per vices, confirmare, ne a 'prono brutorum inceſſu et copioſo affluxu humorum debilitetur.' Ophthal. c 2. ſect. 2.

THE muſculus ſuſpenſorius being in the porpuſs, as well as brutes, Dr. Tyſon thinks the uſe of it is not to ſuſpend the bulk of the eye, but rather by its equal contraction of the ſclerotis to render the ball of the eye more or leſs ſpherical, and ſo fitter for viſion. Tyſon's Anat. of the Porpuſs, p. 39.

[h] 'MUSCULUS obliquus inferior oritur a peculiari quodam 'foramine in latere orbitæ ocularis facto, (contra quam in cæteris, &c.) quo fit ut ex una parte a muſculo trochleari ex 'altera vero ab hujus muſculi commodiſſima poſitione, oculus 'in æquilibrio quodam conſtitutus, irretorto obtutu verſus objecta feratur, nec plus juſto accedat verſus internum exter- 'numve

abducent muſcles; partly by their peculiar origin, or the addition of the trochlea, which is the caſe of the oblique muſcles [i]; and partly by the natural poſture of the body, and the eye, which is the caſe of the attollent and depriment muſcles. By this ſo curious and exact a libration, not only unſeemly contortion, and incommodious vagations of the eye are prevented, but alſo it is able with great readineſs and exactneſs to apply itſelf to every object.

As to the tunics of the eye, many things might be taken notice of the prodigious fineneſs of the arachnoides, the acute ſenſe of the retina, the delicare

---

'numve canthum; quæ quidem libratio omnino nulla fuiſſet 'abſque hujus muſculi peculiari originatione (cujus ratio omnes 'hujuſque anatomicos latuit.)' And ſo this curious anatomiſt goes on to ſhew farther the ſtupendous artifice of the great Creator in this poſition of the oblique muſcles. Brigg's Nova Viſ. Theor. p. 11. meo libro.

[i] Besides thoſe particular motions which the eye receives from the oblique muſcles, and I may add its libration alſo in ſome meaſure, ſome anatomiſts aſcribe another no leſs conſiderable uſe to them; namely, to lengthen and ſhorten the eye, by ſqueezing and compreſſing it, to make it correſpond to the diſtances of all objects, according as they are nigh or far off. Thus the ingenious Dr. Keil; 'The aqueous humour being the 'thinneſt and moſt liquid, eaſily changeth its figure, when either 'the ligamentum ciliare contracts, or both the oblique muſcles 'ſqueeze the middle of the ball of the eye, to render it oblong 'when

licate tranſparency of the cornea [k], and the firm and ſtrong texture of that and the ſclerotica too; and each of them, in theſe and every other reſpect, in the moſt accurate manner adapted to the place in which it is, and the buſineſs it is there to perform. But for a ſample, I ſhall only take notice of that part of the uvea which makes the pupil. It hath been obſerved by others, particularly by our honourable founder [l] that as we are forced to uſe various apertures to our optic glaſſes, ſo nature hath made a far more complete proviſion in the eyes of animals, to ſhut out too much, and to admit ſufficient light, by the dilatation and contraction of the pupil [m]. But it deſerveth our eſpecial remark, that theſe

---

'when objects are too near us.' Keil's Anat. chap. 4. ſect. 4. See note (*m*), below.

[k] 'Quis vero opifex præter naturam, qua nihil poteſt eſſe 'callidius, tantam ſolertiam perſequi potuiſſet in ſenſibus? quæ 'primum oculos membranis tenuiſſimis veſtivit et ſepſit; quas pri'mum perlucidas fecit, ut per eas cerni poſſet: firmas autem, ut continerentur.' Cic. de Nat. Deor. l. 2. c. 57.

[l] Boyle of Final Cauſes.

[m] It is eaſy to be obſerved, that the pupil openeth in dark places; as alſo when we look at far diſtant objects, but contracts by an increaſe of light, and when the objects are nigh. This motion of the pupil, ſome ſay, is effected by the circular and ſtrai

theſe pupils are in divers animals of divers forms, according to their peculiar occaſions. In ſome particularly in man, it is round; that being the moſt proper figure for the poſition of our eyes, and the uſe we make of them both by day and night. In ſome other animals it is of a longiſh form; in ſome tranſverſe [n], with its aperture large, which is an admirable proviſion for ſuch creatures to ſee the better laterally, and thereby avoid inconveniences, as well as help

---

ſtrait fibres of the uvea, and ſome attribute it to the ligamentum cilliare. Yet I have no great doubt but that they both concur in that action, and that the ligamentum ciliare doth, at the ſame time the pupil opens or ſhuts, dilate or compreſs the cryſtalline and bring it nigher unto, or carry it farther off the retina. For the ſtructure of the ligamentum ciliare, and its two ſorts of fibres, drawn with the help of a microſcope, I ſhall refer to Mr. Cowper's Anat. T. 11.

[n] 'In bove, capra, equo, ove, et quibuſdam aliis elliptica 'eſt [pupilla] ut eo magis in hiſce forſan animalibus, quæ pro- 'no inceſſu victum in agris quæritant, radios laterales ad mala 'et incommoda utrinque devitanda admittat. Brigg's Oph. c. 7. ſect. 6.

'Homini erecto, aliiſque, &c. caput, erigere, et quaquaverſus 'circumſpicere ſolitis, plurima ſimul objecta, tum ſupra, tum in- 'fra, tum e latere utroque—— viſu excipiuntur; quapropter ocu- 'lis pupilla rotunda eſſe debet—— Attamen bovi, &c. caput fere 'ſemper pronum——gerentibus, tantumque coram, et paulo a la- 'tere obverſantur, intuitu opus eſt: quapropter pupilla——ob- 'longa eſt,' &c. Willis de Anim. Brut. p. 1. c. 15.

them to gather their food on the ground, both by day and night. In other animals the fiſſure of the pupil is erect [o], and alſo capable of opening wide, and ſhutting up cloſe. The latter of which ſerves to exclude the brighter light of the day, and the former to take in the more faint rays of the night, thereby enabling thoſe nocturnal animals (in whom generally this erect form of the pupil is) to catch their prey with the greater facility in the dark [p], to ſee upwards and

---

[o] THUS cats (their pupils being erect, and the ſhutting of their eye-lids tranſverſe thereunto) can ſo cloſe their pupil, as to admit of, as it were, only one ſingle ray of light; and by throwing all open, they can take in all the fainteſt rays. Which is an incomparable proviſion for theſe animals, that have occaſion to watch and way-lay their prey both by day and night.

[p] There is, beſides this large opening of the pupil, in ſome nocturnal animals, another admirable proviſion, enabling them to catch their prey in the dark; and that is, a radiation of the eyes: of which Dr. Willis thus; 'Hujus uſus eſt oculi pupillam, 'quaſi jubare inſito, illuminare, ut res noctu, et in tenebris po'ſitas conſpicere valeat: quare in fele plurimum illuſtris eſt: at 'homini, avibus et piſcibus deeſt.' This illumination he ſpeaks of, is from the tapetum, in the bottom of the eye, or the ſhining of the retina, round the optic nerve.

BESIDES which, he ſaith, the iris hath a faculty alſo, in ſome of darting out rays of light, ſo as to enable them to ſee in the dark; of which he tells this ſtory: 'Novi quendam cerebro ca'lidiori præditum qui poſt uberiorem vini generoſi potum in nocte and downwards, to climb &c. Thus much for the tunics.

The next thing I ſhall take notice, of will relate to the humours of the eye, and that only concerning the mechaniſm of the cryſtalline humour; not its incomparable tranſparency; nor its exact lenticular from; nor its curious araneous membrane q, that conſtringeth and dilateth it, and

---

'nocte atrata ſive tenebris profundis, literas diſtincte legere po-'tuit. Cujus ratio videtur eſſe, quod ſpiritus animales velut ac-'cenſi, adeoque ab hac iride irradiantes, jubare inſito medium il-'luminabant. Willis, ibid.

Such another thing, Pliny tells us, was reported of Tiberius Cæſar; 'Ferunt Tib. Cæſ. nec alii genitorum mortalium, fuiſſe 'naturam, ut expergefactus noctu pauliſper, haud alio modo 'quam luce clara, contueretur omnia.' Nat. Hiſt. l 11. c. 37.

So Dr. Briggs; 'Virum ſane callidæ indolis novi in comitatu 'Bedfordienſi degentem, qui oculis felineis—— donatus eſt: adeo 'ut epiſtolam——mire admodum in loco obſcuro (ubi eadem mihi 'vix apparuit) perlegit. Hujus vero oculi, niſi quod pupillas in-'ſigniores obtinuere, ab aliorum formatione neutiquam diſcrepabant' ' Ophthal. c. 5. ſect. 12.

[q] The tunica aranea is taken notice of by friar Bacon, who calls it, tela aranea, and ſaith, 'in hac continetur——glaciale 'vel cryſtallinum.' Rog. Bacon's Perſpect. Diſtinct. 2. c. 3 The wrinkling of this, and the cornea as the ſkin is of old perſons. he thinks is the cauſe of the obſcurity of the ſight in ſuch perſons. Bacon, ib. par. 2. cap. 2. But this tunic ſome. deny, and others allow of: Dr. A. M. of Trinity-College, Dublin, (in his Relat. of Anat. Obſ. on his eyes of animals, in a letter to

and ſo varieth its focus, (if any ſuch variation there be, as ſome affirm with great probability); nor

to Mr. Boyle, An. 1682. annexed to his Anat. Account of the Elephant burnt in Dublin, p. 57.) affirms the tunica aranea, and ſaith, 'I have often ſeen it before it was expoſed to the air one 'minute, notwithſtanding what Dr. Briggs' ſaith to the con'trary, &c. But Dr. Brigg's opinion is 'Humor cryſtallinus, 'niſi æri diutius expoſitus, vel leniter coctus, inſtar lactis, cu'ticulam non acquirit: quæ vero improprie, tunica aranea dici'tur, cum tantum adventitia, ut in oculo bovis recens erecto 'appareat.' Briggs' Ophthalm, c. 3.

The cryſtalline humour being of a double ſubſtance, outwardly like a jelly, towards the centre as conſiſtent as hard ſuet, upon occaſion whereof its figure may be varied; which variation may be made by the ligamentum ciliare; Dr. Grew doth, upon theſe accounts, not doubt to aſcribe to the ligamentum ciliare, a power of making the cryſtaline more convex, as well as of moving it to or from the retina. See Grew's Coſmolog. Sacr. l. 1, c. 4. Now, it is certain, by the laws of optics, that ſomewhat of this is abſolutely neceſſary to diſtinct viſion, inaſmuch as the rays proceeding from nigh objects do more diverge, and thoſe from diſtant objects leſs: which requires either that the cryſtalline humour ſhould be made more convex, or more flat; or elſe an elongation, or ſhortening of the eye, or of the diſtancce between the cryſtalline humour and the retina.

But although Dr. Briggs, ſo good a judge, denies the tunica cryſtallina, contrary to the opinion of moſt former anatomiſts; yet there is great reaſon to conclude he was in a miſtake, in my opinion, from the obſervations of the French anatomiſt of the cryſtalline of the eye of the gemp or chamois, who ſay 'the membrana arachnoides was very thick, and hard, ſo that 'it was eaſily ſeparated from the cryſtallinus.' P. 145.

nor laſtly, its admirable approach to or from the retina, by the help of the ciliar ligament [r], ac-

THE ſame anatomiſts alſo favour the ſurmiſe of Dr. Grew, ‘ This [contraction of the fibres of the ligamentum ciliare on one ‘ ſide, and dilatation on the other]would make us think that theſe ‘ fibres of the ligamentum ciliare, are capable of contraction, ‘ and voluntary dilatation, like that of the fibres of the muſcles ; ‘ and that this action may augment, or diminiſh the convexity ‘ of the cryſtallinus, according as the need which the diſtance ‘ of the objects may make it to have on the eye, to ſee more ‘ clearly and diſtinctly.’ Anat. Deſcr. of a bear, p. 49.

SINCE my penning the foregoing notes, having as critically as I could, diſſected many eyes of birds, beaſts, and fiſhes, I manifeſtly found the membrana arachnoides, and will undertake to ſhew it any one, with great eaſe and certainty. It is indeed ſo tranſparent, as not to be ſeen diſtinct from the cryſtalline. But if the cornea and uvea be taken off before, or the vitreous humour behind it, and the outſide of the cryſtalline be gently cut, the arachnoides may be ſeen to open, and the cryſtalline will eaſily leap out, and part from the ligamentum ciliare ; which otherwiſe it would not do : for it is by the arachnoides braced to the ligamentum ciliare. This membrane or tunic, in the ox, is ſo ſubſtantial and ſtrong, though thin, that it yields to, or ſinks under the ſharpeſt lancet, and requires (for ſo thin and weak a membrane in appearance) a ſtrong preſſure to pierce it.

[r] As birds and fiſhes are in divers things conformable, ſo in ſome ſort they are in their eye, to enable it to correſpond to all the convergences, and divergences of the rays, which the variation of each of the mediums may produce. For this ſervice the tunica choroides [in fiſhes] hath a muſculous ſubſtance at the bottom of it, lying round the optic nerve, at a ſmall diſtance from it ; by which means I imagine they are able to contract and dilate the choroides, thereby to lengthen and ſhorten the eye

according as objects are far off or near; becauſe theſe things are what are uſually taken notice of;

eye: for the helping in which ſervice, I imagine it is that the choroides and ſclerotica, are in a great meaſure parted, that the choroides may have the greater liberty of acting upon the humours within.

But in birds, I have myſelf found, that although the choroides be parted from the ſclerotica, yet the choroides hath no muſcle, but inſtead thereof, a curious pectinated work, ſeated on the optic nerve, repreſented in Fig. 2. In which, c. a. e. b. d repreſents the choroides and ſclerotica; a. b. the part of the optic nerve that is within the eye; v. v. v. the vitreous humour; a. f. g. b. the pecten; h. i. the cryſtalline. For the reception of this pecten, the optic nerve comes farther within the eye, than in other creatures. The ſtructure of this pecten is very like that of the ligamentum ciliare: and in the eye of a magpye, and ſome others I could perceive it to be muſculous towards the bottom. This pecten is ſo firmly fixed unto or embodied in the vitreous humour, that the vitreous humour hangs firmly to it, and is not ſo eaſily parted from it. By which means all the motions of the pecten are eaſily communicated to the vitreous humour, and indeed to all contained in the choroides. And foraſmuch as the cryſtalline is connected to the vitreous humour, therefore alſo the alterations in the vitreous humour affect alſo the cryſtalline; and the cryſtalline hereby brought nearer unto, or farther from the retina, as occaſion is.

Besides all which obſervables in the choroides, and inner eye, I have alſo found this farther remarkable in the ſclerotica, and outer-part of the eye of birds, viz. that the fore-part of the ſclerotica is horny and hard, the middle part thin and flexible, and braces intervene between the fore and hind-part, running between the choroides and ſclerotica; by which means the cornea, of; but that which I ſhall obſerve is, the prodigious art and finery of its conſtituent parts, it being, according to ſome late nice microſcopical ob-

and back-part of the eye, are brought to the ſame conformity, that the reſt of the eye hath.

THE great end and deſign of this ſingular and curious apparatus in the eyes, both of birds and fiſhes, I take to be, 1. To enable thoſe creature to ſee at all diſtances, far off, or nigh; which, eſpecially in the waters, requireth a different conformation of the eye. In birds alſo, this is of great uſe, to enable them to ſee their food at their bill's end, or to reach the utmoſt diſtances their high flights enable them to view; as to ſee over great tracts of ſea or land, whither they have occaſion to fly; or to ſee their food or prey, even ſmall fiſhes in the waters, and birds, worms, &c. on the earth, when they ſit upon trees high rocks or are hovering high in the air. 2. To enable thoſe animals to adapt their eye to all the various refractions of their medium. Even the air itſelf varies the refractions, according as it is rarer or denſer, more or leſs compreſſed; as is manifeſt from the learned and ingenious Mr. Lowthorp's experiment in Phil. Tranſ. N° 257. and ſome other experiments ſince of the before-commended Mr. Hawkſbee, both in natural, rarified and compreſſed air; in each of which, the refractions conſtantly varied in exact proportion to the rarity or denſity of the air. Vide Hawkſbee's Exp. p. 175. &c.

BESIDES this conformity in general, between the eyes of birds and fiſhes, Du Hamel tells us of a ſingular conformity in the cormorant's eye, and that is, that the cryſtalline is globous, as in fiſhes, to enable it to ſee and purſue its prey under water: which J. Faber, in Mr. Willoughby, ſaith they do 'with wonderful ſwiftneſs, and for a long time. Will. Ornithol. p. 329.

obſervations[f], compoſed of divers thin ſcales, and theſe made up of one ſingle minuteſt thread or fibre, wound round and round, ſo as not to croſs one another in any one place, and yet to meet, ſome in two, and ſome in more different centres; a web not to be woven, an optic lens, not to be wrought by any art leſs than infinite wiſdom.

Lastly, To conclude the parts of this admirable organ, I ſhall only make one remark more, and that about its nerves. And here among others, the admirable make of the optic

---

[f] The cryſtalline humour, when dried, doth manifeſtly enough appear to be made up of many very thin ſpherical laminæ, or ſcales lying upon one another. Mr. Lewenhoeck reckons there may be two thouſand of them in one cryſtalline, from the outermoſt to the centre. Every one of theſe ſcales, he ſaith, he hath diſcovered to be made up of one ſingle fibre, or fineſt thread wound, in a moſt ſtupendous manner, this way, and that way, ſo as to run ſeveral courſes and meet in as many centres, and yet not to interfere, or croſs one another, in any one place. In oxen, ſheep, hogs, dogs, and cats, the thread ſpreads into three ſeveral courſes, and makes as many centres; in whales five; but in hares and rabbets only two. In the whole ſurface of an ox's cryſtalline, he reckons there are more than twelve thouſand fibres juxtapoſited. For the clear and right underſtanding of the manner of which admirable piece of mechaniſm, I ſhall refer to his cuts and deſcriptions in Phil. Tranſ. N° 165, and 193. The truth hereof I have heard ſome ingenious men queſtion; but it is what I myſelf have ſeen, and can ſhew to any body, with the help of a good microſcope.

nerves

nerves might deſerve to be taken notice of in the firſt place, their medullary part [t] terminating in the brain itſelf, the teguments propagated from the meninges, and terminating in the coats of the eye, and their commodious inſertions into the ball of the eye, in ſome directly oppoſite to the pupil of the eye, in others obliquely towards one ſide [u]. But moſt of theſe things have been treated of, and the convenience hereof ſet forth, by others that have written of God's works. I ſhall therefore take notice only of one wiſe proviſion the Creator hath made about the motion of the eye, by uniting into one, the third pair of nerves, called the motory nerve [v], each of which ſending its branches into each muſcle of each eye, would cauſe a diſtortion in the eyes; but being united into one, near their inſertion into the brain, do thereby cauſe both eyes to have the ſame motion; ſo that when one eye is moved this way and that way, to this and that object, the other eye is turned the ſame way alſo.

---

[t] S. Malpighi obſerved the middle of the optic nerve of the ſword-fiſh to be nothing elſe but a large membrane, folded according to its length in many doubles, almoſt like a fan, and inveſted by the dura mater; whereas in land-animals it is a bundle of fibres. Vide Phil. Tranſ. N° 27.

[u] 'CERTISSIMUM eſt, quod in omnibus oculis humanis, quos 'ſaltem mihi diſſecare contingit, nervus opticus pupillæ e dia- 'metro opponitur,' &c. Briggs' Ophthal. cap. 3. ſect. 15. Ita Willis de Anim. Brut. p. 1. c. 15.

'NERVI optici in nobis, item in cane, fele, et in cæteris for- 'ſan animalibus calidis, ad fundum oculi delati pupillæ regioni 'proſpiciunt, dum interim in aliis quadrupedibus, uti etiam in 'piſcibus et volucribus, oblique ſemper tunicæ ſclerotidi inſe- 'runtur.' Willis ib. cap. 7. ſect. 11.

THUS from this tranſient and ſlight view, I may call it, of the parts of the eye, it appears what an admirable artiſt was the contriver thereof. And now in

THE ſeventh and laſt place, let us conſider what proviſion this admirable artiſt hath made for the guard and ſecurity of this ſo well formed organ [w]. And here we ſhall find the guard

equi

---

[v] 'THIS pair is united at its riſe; whence is commonly 'drawn a reaſon why one eye being moved towards an object 'the other is directed alſo to the ſame,' Gibſon's Anat. book iii. chap, 11. So Bartholine Anat. Libellus iii. cap. 2.

[w] AMONG all the other ſecurities the eye hath, we may reckon the reparation of the aqueous humour; by which means the eye when wounded, and that in all appearance very dangerouſly too, doth often recover its ſight: of which Bern. Verzaſacha gives divers examples ancient and modern. One is from Galen, of a boy ſo wounded, that the cornea fell, and became flaccid, but yet recovered his ſight. Other ſuch like inſtances he gives from

Realdus

equivalent to the uſe and excellency of the part. The whole organ fortified and fenced with ſtrong compact bones, lodged in a ſtrong, well made ſocket, and the eye itſelf guarded with a nice made

---

Realdus Columbus, Rhodius, and Tulpius; and one that he cured himſelf, in theſe words; ‘Ego in nobiliſſimi viri filiola ſimilem caſum obſervavi; hæc dum levibus de cauſis cum fratre altercarit, iſte iracundia percitus cultellum ſcriptorium apprehendit, et ſororis occulo vulnus infligit, inde humor aqueus effluxit. Vocatus præſentem chirurgum juſſi ſequens collyrium anodynum et exſiccans tepide ſæpius admovere. ℞ aq. Plantag. ʒ iv. Roſar. Sanicul. Euphraſ. ana Trochiſc. alb. Rhaſ cum Opio ℈ ij. Tutiæ pp. ℈ j. Croci orient. ℈ ß. M. Hoc collyrium inflammationem compeſcuit, vulnus ſiccavit et ſanavit. Hinc poſt aliquot menſes humor aqueus ſuccrevit. Nam viſus, ſed debilior, cum ſummo parentum gaudio redivit.’ B. Verzaſachæ Obſerv. Medicæ. Obſ. 14.

ANOTHER cure of this kind, was experimented by Dr. Daniel Major, upon a gooſe, Ann. 1670. the aqueous humour of both whoſe eyes they let out, ſo that the eyes fell, and the gooſe became quite blind: but without the uſe of any medicine, in about two days time, nature repaired the watery humour again, the eyes returned to their former turgency, and the gooſe was in a week after produced ſeeing, before twenty eight or thirty ſpectators. Ephem. Germ. T. 1. Add. ad Obſ. 217.

FROM the ſame cauſe, I doubt not it was that the eye of a gentleman's daughter, and thoſe of a cock, when wounded, ſo that the cornea ſunk, were reſtored by a Lithuanian chymiſt, that paſſed for a conjurer, by the uſe of a liquor found in May, in the veſiculæ of elm. Of which ſee Mr. Ray's Catal. Cantab. in Ulmus, from Henr. ab Heers.

cover [x]. Its humour, and its inward tunics, are indeed tender, proportionate in their tender, curi-

---

[x] 'Palpebræ, quæ, ſunt tegumenta oculorum, molliſſimæ tactu, ne læderent aciem, aptiſſimæ factæ, et ad claudendas 'pupillas, ne quid incideret, et ad aperiendas; idque providit 'ut identidem fieri poſſet cum maxima celeritate. Munit æque 'ſunt palpebræ tanquam vallo pilorum: quibus et apertis oculis, ſi quid incideret, repelleretur, et ſomno conniventibus, cum 'oculis ad cernendum non egeremus, ut qui, tanquam involuti, 'quieſcerent. Latent præterea utiliter, et excelſis undique partibus ſepiuntur. Primum enim ſuperiora ſuperciliis obducta ſudorem a capite, et fronte defluentem repellunt. Genæ deinde, 'ab inferiore putantur ſubjectæ, leviterque eminentes.' Cic. de Nat. Deor. l. 2. c, 57.

Tully, in the perſon of a Stoic, having ſo well accounted for the uſe of the eye-lids, I ſhall, for a further manifeſtation of the Creator's contrivance and ſtructure of them, take notice of two or three things: 1. They conſiſt of a thin and flexible, but ſtrong ſkin, by which means they the better wipe, clean, and guard the cornea. 2. Their edges are fortified with a ſoft cartilage, by which means they are not only enabled the better to do their office, but alſo to cloſe and ſhut the better. 3. Out of theſe cartilages grows a palliſade of ſtiff hairs, of great uſe to warn the eye of the invaſion of dangers, to keep off motes, and to ſhut out too exceſſive light, &c. and at the ſame time to admit of, through their intervals, a ſufficient paſſage for objects to approach the eye. And it is remarkable, that theſe hairs grow but to a certain, commodious length, and need no cutting as many other hairs of the body do: alſo, that their points ſtand out of the way, and in the upper-lid bend upwards as they do downwards in the lower lid, whereby they are well adapted to their uſe. From which laſt obſervables, we may learn how critical and nice the great author of nature hath been, in even the leaſt and moſt trivial conveniencies belonging to animal bodies; for which reaſon I have added it to Tully's remarks. And more curious uſes; but the coats without are context and callous, firm and ſtrong. And in ſome animals

---

might have been added too, as particularly concerning the curious ſtructure and lodgment of the right muſcle, which opens the eye-lids; the the orbiculars, or circular one that ſhuts them; the nice apparatus of glands that keep the eye moiſt, and ſerve for tears; together with the reaſon why man alone, who is a ſocial animal, doth exhibit his ſocial affections by ſuch outward tokens as tears; the nerves alſo, and other organs acting in this miniſtry. I might alſo ſpeak of the paſſages for diſcharging the ſuperfluous moiſture of the eyes through the noſtrils, and much more of the like kind. But it would take up too much room in theſe notes; and therefore it ſhall ſuffice to give only ſuch hints as may create a ſuſpicion of a noble œconomy and contrivance in this, I had almoſt ſaid, leaſt conſiderable part of the eye. But for particulars I ſhall refer to the anatomiſts; and for ſome of theſe things, particularly to Dr. Willis's Cereb. Anat. and de Anim. Brut. and Mr. Cowper's elegant cuts in the 11th tab. of his Anatomy.

To the eye-lid, we may add another guard afforded the eyes of moſt quadrupeds, birds, and fiſhes, by the nictitating membrane, which Dr. Willis gives this account of; 'Plurimis [animalibus] quibus muſculus ſuſpenſorius adeſt (which limitation he needed not to have added) etiam alter membranoſus conceditur, qui juxta interiorem oculi canthum ſitus quando elevatur, oculi globum fere totum obtegit. Hujus uſus eſſe videtur, ut cum beſtiæ inter gramina, &c. capita ſua propter victum capeſſendum demergunt, hic muſculus oculi pupillam ne a ſtipularum incurſu feriatur, occulit munitque. De Anim. Brut. p. 1. c. 15.

THIS membrane man hath not, he having little occaſion to thruſt his head into ſuch places of annoyance, as beaſts, and other animals; or if he hath, he can defend his eyes with his hands mals, particularly birds [y], ſome part of thoſe tunicles have the nature and hardneſs of bone or horn.

But for creatures, whoſe eyes, like the reſt of their body, are tender, and without the guard of bones; their nature hath provided for this neceſſary and tender ſenſe, a wonderful kind of guard, by endowing the creature with a faculty of withdrawing its eyes into its head [z], and lodging them in the ſame ſafety with the body.

THUS

---

hands. But birds, (who frequent trees and buſhes, and quadrupeds, (hedges and long graſs) and who have no part ready, like the hand, to fence off annoyances; theſe, I ſay, have this incomparable proviſion made for the ſafety of their eyes. And for fiſhes, as they are deſtitute of eye-lids, becauſe in the waters there is no occaſion for a defenſative againſt duſt and motes, offenſive to the eyes of land-animals, nor to moiſten and wipe the eyes as the eye-lids do, ſo the nictitating membrane is an abundant proviſion for all their occaſions, without the addition of the eyelids,

AND now, if we reflect, are theſe the works of any thing but a wiſe and indulgent agent?

[y] ALTHOUGH the hardneſs and firmneſs of the adnata, or ſclerotica in birds, is a good guard to their eyes, yet I do not think it is made thus ſo much for a defence, as to miniſter to the lengthening and ſhortening the eye, mentioned before in note (*i*) p. 138, &c.

[z] ‘ COCHLEIS oculorum vicem cornicula bina prætentu im-

plent

Thus have I ſurveyed this firſt ſenſe of animals, I may ſay in a curſory, not accurate, ſtrict manner, conſidering the prodigious workmanſhip thereof; but ſo, as abundantly to demonſtrate it to be the contrivance, the work of no leſs a being than the infinite, wiſe, potent, and indulgent Creator [a]! For none leſs could compoſe ſo admirable an organ, ſo adapt all its parts, ſo adjuſt it to all occaſions, ſo nicely provide for every uſe, and for every emergency: to a word, none leſs than God could, I ſay, thus contrive, order, and provide an organ, as magnificent and curious as the ſenſe is uſeful; a ſenſe without which, as all the animal world would be in perpetual darkneſs, ſo it would labour under perpetual inconveninencies, be expoſed to perpetual harms and ſuffer perpetual wants and diſ-

---

' plent Plin. Nat. Hiſt l 11. c. 37. See more in the eyes of ſnails before in note (*y*), p. 128; and in note (*a*), p. 129, I ſaid that I ſuſpected moles alſo might thruſt out, or withdraw their eyes more or leſs within the hair or ſkin.

[a] The diligent Sturmius was fully perſuaded there could not be any ſpeculative atheiſm in any one that ſhould well ſurvey the eye. 'Nobis,' ſaith he, fuit perſuaſiſſimum, atheiſmum, 'quem vocant ſpeculativum, h. e. obfirmatam de Deitate in 'univerſo nulla perſuaſionem, habere locum aut inveniri non 'poſſe in eo homine, qui vel unius corporis organici, et ſpeci- 'atim oculi fabricam attento animo aſpexerit.' Sturm. Exerc Acad. 9. de Viſ. Organ. et Rat. in Epilogo.

treſſes. But now by this admirable ſenſe, the great God, who hath placed us in this world hath as well provided for our comfortable reſidences in it; enabled us to ſee and chuſe wholeſome, yea, delicate food: to provide ourſelves uſeful, yea, gaudy cloathing, and commodious places of habitation and retreat. We can now diſpatch our affairs with alacrity, and pleaſure, go here and there as our occaſion calls us. We can, if need be, ranſack the whole globe, penetrate into the bowels of the earth, deſcend to the bottom of the deep, travel to the fartheſt regions of this world to acquire wealth to increaſe our knowledge, or even only to pleaſe our eye and fancy. We can now look about us, diſcern and ſhun the precipices and dangers which every where encloſe us, and would deſtroy us. And thoſe glorious objects which fill the heavens and the earth, thoſe admirable works of God, which every where ſurround us, and which would be as, nothing to us, without being ſeen, do, by means, of this noble ſenſe, preſent their glories to us [b], and fill us with admiration and pleaſure. But I need not expatiate in the uſefulneſs and praiſes of this ſenſe which we receive the benefit of every moment, and the want, or any defect of which, we lament among our greateſt misfortunes.

---

[b] THE glorious landſkips, and other objects that preſent themſelves to the eye, are manifeſtly painted on the retina, and that not erect, but inverted as the laws of optics require and is manifeſt to the eye from monſieur Cartes's experiment, of laying bare the vitreous humour on the back part of the eye, and clapping over it a bit of white paper or the ſkin of an egg; and then placing the fore-part of the eye to the hole of the window of

Leaving then this ſenſe, I ſhall proceed to the other four but more briefly treat of them, by reaſon we have ſo ample a ſample of the divine art in the laſt, and may preſume that the ſame

---

of a darkened room. By which means we have a pretty landſkip of the objects abroad invertedly painted on the paper, on the back of the eye. But now the queſtion is, how in this caſe the eye comes to ſee the objects erect? Monſieur Cartes's anſwer is 'Notitia illius ex nulla imagine pendet, nec ex ulla actione ab 'objectis veniente, ſed ex ſolo ſitu exiguarum partium cerebri, 'e quibus nervi expullulant.———E. G. Cogitandum in oculo '——ſitum capillamenti nervi optici——reſpondere et alium 'quendam partis cerebri——qui facit ut anima ſingula loca cognoſcat, quæ jacet in recta, aut quaſi recta linea; ut ita mirari 'non debeamus corpora in naturali ſitu videri, quamvis imago in 'oculo delineata contrarium habeat.' Dioptr. c 6. But our moſt ingenious Mr. Molyneux anſwereth thus; 'The eye is 'only the organ or inſtrument, it is the ſoul that ſees by means of the eye. To inquire then how the ſoul perceives the ob'ject erect, by an inverted image, is to inquire into the ſoul's 'faculties——But erect and inverted are only terms of relation 'to up and down; or farther from, or nigher to the centre of 'the earth, in parts of the ſame thing.——But the eye, or viſive faculty takes no notice of the internal poſture of its own 'parts, but uſeth them as an inſtrument only, contrived by na'ture for the exerciſe of ſuch a faculty.———Let us imagine, 'that the eye (on its lower part) receives an impulſe [by a ray 'from ſame is exerted in all as well as one. For a demonſtration of which, let us, in the next place carry our ſcrutiny to the ſenſe of hearing.

'from the upper part of the object] muſt not the viſive faculty 'be neceſſarily directed hereby to conſider this ſtroke, as com- 'ing from the top rather than the bottom [of the object] and 'conſequently be directed to conclude it the repreſentation of the top? Hereof we may be ſatisfied, by ſuppoſing a man 'ſtanding on his head. For here, though the upper parts of the 'objects are painted on the upper parts of the eye, yet the ob- 'jects are judged to be erect. What is ſaid of erect, and inverſe, 'may be underſtood of ſiniſter and dexter.' Molyn. Dioptr. Nov. part 1. prop. 28.

CHAP. III.

OF THE SENSE OF HEARING.

CONCERNING the ſenſe of Hearing, I ſhall take notice of two things, the organ, and its object, ſound.

I. FOR the organ the ear; I ſhall paſs by its convenient number of being double, which, as in the laſt ſenſe, ſerves for the commodious hearing every way round us; as alſo wiſe a proviſion for the utter loſs or injury[c] of one of the ears but I ſhall

---

[c] I PRESUME it will not be ungrateful to take notice here of the admirable, as well as uſeful ſagacity of ſome deaf perſons, that have learned to ſupply their want of hearing by underſtanding what is ſaid by the motion of the lips. My very ingenious friend, Mr. Waller, R. S. Secr. gives this account: 'There live now, and have from their birth, in our town, a 'man

I ſhall a little inſiſt upon its ſituation, and its admirable fabric and parts.

'man and his ſiſter, each about fifty years old, neither of which 'have the leaſt ſenſe of hearing,—yet both of theſe know, by 'the motion of the lips only, whatever is ſaid to them, and 'will anſwer pertinently to the queſtion propoſed to them—— 'The mother told me they could hear very well, and ſpeak 'when they were children, but both loſt that ſenſe afterwards, 'which makes them retain their ſpeech; though that, to per-'ſons not uſed to them, is a little uncouth and odd, but intel-'ligible enough.' Phil. Tranſ. N° 312.

Such another inſtance is that of Mr. Goddy. miniſter of St. Gervais in Geneva, his daughter. 'She is now about fixteen years old. Her nurſe had an extraordinary thickneſs of hear-'ing; at a year old, the child ſpake all thoſe little words that 'children begin to ſpeak at that age.——At two years old, they 'perceived ſhe had loſt her hearing, and was ſo deaf, that ever 'ſince though ſhe hears great noiſes, yet ſhe hears nothing that 'one can ſpeak to her.—But by obſerving the motions of the 'mouth and lips of others ſhe hath acquired ſo many words 'that out of theſe ſhe hath formed a ſort of jargon, in which 'ſhe can hold converſation whole days with thoſe that can ſpeak 'her own language. I could underſtand ſome of her words, but 'could not comprehend a period, for it ſeemed to be but a con-'fuſed noiſe. She knows nothing that is ſaid to her, unleſs ſhe 'ſeeth the motion of their mouths that ſpeak to her; ſo that in 'the night, when it is neceſſary to ſpeak to her, they muſt light 'a candle. Only one thing appeared the ſtrangeſt part of the 'whole narration: ſhe hath a ſiſter, with whom ſhe hath practiſ-'ed her language more than with any other: and in the night 'by laying her hand on her ſiſter's mouth, ſhe can perceive by 'that what ſhe ſaith, and ſo can diſcourſe with her in the night.' Biſhop Burnet's Let. 4. p. 248.

1. It is ſituated in the moſt convenient part of the body, like as I ſaid the eye is, in a part near the common ſenſory in the brain, to give the more ſpeedy information; in a part where it can be beſt guarded, and where it is moſt free from annoyances and harms itſelf, and where it gives the leaſt annoyance and hindrance to the exerciſes of any other part; in a part appropriated to the peculiar uſe of the principal ſenſes, in the moſt lofty, eminent part of the body, where it can perceive the moſt objects, and receive the greateſt information: and laſtly, in a part in the neigbourhood of its ſiſter ſenſe the eye, with whom it hath peculiar and admirable communication by its nerves, as I intend to ſhew in its proper place. In reſpect then of its ſituation and place in the body, this ſenſe is well deſigned and contrived, and may ſo far be accounted the work of ſome admirable artiſt. But,

2. If we ſurvey its fabric and parts, it will appear to be an admirable piece of the divine wiſdom, art, and power. For the manifeſtation of which, let us diſtinctly ſurvey the outward and the inward part of its curious organ.

1. For the outward ear: if we obſerve its ſtructure in all kinds of animals, it muſt needs be acknowledged to be admirably artificial, it

being ſo nicely prepared and adjuſted to the peculiar occaſions of each reſpective animal. In man[d], it is of a form proper for the erect poſture of his body. In birds, of a form proper for flight; not protuberant, becauſe that would obſtruct their progreſs, but cloſe and covered, to afford the eaſier paſſage through the air. In quadrupeds, its form is agreeable to the poſture, and ſlower motion of their bodies: and in theſe too, various, according to their various occaſions. In ſome large, erect, and open, to hear the leaſt approaches of danger [e], in others covered, to keep out noxious bodies. In the ſubterraneous quadrupeds, who are forced to mine and dig for their food and habitation, as a protuberant ear, like that of other quadrupeds, would obſtruct their labours, and be apt to be torn and injured; ſo they have the contrary [f];

---

[d] I cannot but admire that our moſt eminent modern anatomiſts ſhould not agree, whether there be any muſcles in the outward ear of man or not. Dr. Keil ſaith there are two; Dr. Drake the ſame number; and Dr. Gibſon makes them to be four. So alſo doth monſieur Dionis, and ſo did the ancient anatomiſts: but Dr. Schelhammer expreſsly denies there are any, and ſaith, ‘ Seduxit autem reliquos brutorum anatome, in quorum pleriſque tales muſculi plures inveniuntur; putarunt autem fortaſſis ignominioſum homini, ſi non et his inſtructus eſſet, et minus inde perfectum animal fore.’ Schel. de Auditu, p. 1. c. 1. ſect. 7. But Valſalve, who wrote very lately, and is very accurate in his ſurvey of the ear, ſaith, ‘ Muſculi auriculæ poſteriores quandoque quatuor, quandoque duo; ſed ut plurimum tres adnotantur; et quando ſolum duo ſe manifeſtant, tunc unus ex illis duplicato tendine verſus concham deferri ſolet. Horum muſculorum in numero varietatem non ſolum in diverſis; verum etiam in eodem ſubjecto quandoque vidi——Ex quibus differentiis ſubortæ ſunt auctorum diſcrepantiæ in horum muſculorum numero, et poſitu:———quod non eveniſſet, ſi pluries in diverſis corporibus iidem muſculi quæſiti eſſent.’ Ant. Mar. Valſalva de Aur. Human. c. 1. ſect. 6. But Dr. Drake thinks ſome of Valſalva's muſcles the product of fancy. Mr. Cowper makes them to be three, one attollent, and two retrahent muſcles. See Anat. Tab. 12.

---

[e] 'Inter cætera [animalia aurita] maximè admirabilis eſt 'auris leporinæ fabrica, quod cum timidiſſimum animal ſit, et 'prorſus inerme; natura id tum auditu acutiſſimo, tanquam 'hoſtium exploratore ad præſentienda pericula, tum pedibus ceu 'armis ad currendum aptis muniſſe videtur.' A. Kircher's Phonurg. l. 1. ſect. 7. Technaſ. 2.

[f] MOLES have no protuberant ear, but only a round hole between the neck and ſhoulder; which ſituation of it, together with the thick, ſhort fur that covers it, is a ſufficient defenſative againſt external annoyances. The meatus auditorius is long round, and cartilaginous, reaching to the under part of the ſkull. Round the inſide runs a little ridge, reſembling two threads of a ſkrew; at the bottom whereof is a pretty inlet leading to the drum, made, on one ſide, with the aforeſaid cochleous ridge, and on the other with a ſmall cartilage. I obſerved there was cerumen in the meatus.

As to the inner ear, it is ſomewhat ſingular, and different from that of the other quadrupeds, and much more from birds; although I have met with ſome authors that make it agreeable with that of birds. There are three ſmall bones only, all hollow, by which the drum, to uſe the old appellation, or the membrana tympani, as others call it, acteth upon the auditory nerve.

their ears ſhort, lodged deep and backward in their head, and paſſing to the under part thereof

The firſt is the malleus, which hath two proceſſes nearly of equal length; the longer of which is braced to the membrana tympani, the ſhorter to the ſide of the drum, or os petroſum; the back part of it reſembles the head and ſtalk of a ſmall muſhroom, ſuch as are pickled. On the back of the malleus lies the next ſmall bone, which may be called the incus, long, and without any proceſs, having ſomewhat the form of the ſhort ſcoop wherewith watermen throw the water out of their wherries. To the end of this, the third and laſt ſmall bone is tacked by a very tender brace. This little bone bears the office of the ſtapes, but is only forked without any baſe. One of theſe forks is at one feneſtra, or foramen, the other at another; in which feneſtræ I apprehend the forks are tacked to the auditory nerve. Theſe feneſtræ (equivalent to the feneſtra ovalis, and rotunda in others) are the inlets into the cochlea and canales ſemicirculares, in which the auditory nerve lieth. The ſemicircular canals lie at a diſtance from the drum, and are not lodged, as in other animals, in a ſtrong, thick body of bone, but are thruſt out, within the ſkull, making an antrum, with an handſome arch leading into it, into which a part of the brain enters.

One leg of the malleus being faſtened to the membrana tympani, and the incus to the back of the malleus and the top of that to the top of the ſtapes, and the forks or branches of the ſtapes to the auditory nerve, I obſerved that whenever I moved the membrane, all the little bones were at the ſame time moved, and conſequently the auditory nerve thereby affected alſo.

I HOPE the reader will excuſe me for being ſo particular in this organ only of the mole, a deſpiſed creature, but as notable an example of God's work, as its life is different from that of other quadrupeds; for which reaſon it partly is that I have enlarged on this part differing from that of others, and which no body that

I know

of, and all ſufficiently fenced and guarded. And as for inſects, reptiles, and the inhabitants of the waters, if they enjoy this ſenſe, as there is great reaſon to think they do, it may probably be lodged commodiouſly under the ſame ſecurity and guard, as the ſmelling, or ſome other ſenſe is.

And moreover, as the form of this organ is various in various animals, ſo in each of them its ſtructure is very curious and obſervable, being in all admirably contrived to collect the wandering, circumambient impreſſions and undulations of ſound, and convey them to the ſenſory within. If I ſhould run over the ſeveral genera of animals, we might find a notable proſpect of the handy-work of God [g], even in this ſo in-

---

I know of, hath taken much notice, of and which is not diſcoverable without great patience and application; and partly becauſe by comparing thoſe obſervations with book vii. chap. 2. we may judge how the ſenſe of hearing is performed.

[g] 'Among many varieties both in the inner and outer ear, 'thoſe which appear in the paſſage into the rock-bone, are re-'markable. For in an owl, that perches on a tree or beam, and 'hearkens after the prey beneath her, it is produced farther out 'above than it is below, for the better reception of the leaſt 'ſound. But in a fox, that ſcouteth undereath the prey at rooſt, 'it is for the ſame reaſon produced farther out below. In a 'pole cat, which hearkens ſtrait forward, it is produced behind, 'for

inconſiderable a part of animals. But I ſhall only carry my ſurvey to that of man. And here the firſt thing that offereth itſelf to our view is the helix, with its tortuous cavities, made to ſtop, and collect the ſonorous undulations, to give them a gentle circulation and refraction, and ſo, convey them to the concha, or larger and more capacious round cell at the entrance of the ear. And to bridle the evagation of the ſound, when arrived ſo far, but withal not to make a confuſion thereof, by any diſagreeable repercuſſions, we may take notice of a very curious proviſion in thoſe little protuberances, called the tragus, and antitragus of the outward ear, of a commodious form and texture [h], and conveniently lodged for this uſe. The great convenience and benefit of this form and contrivance of the outward ear, is ſufficiently manifeſt by the want thereof, which cauſeth a ʻ confuſion

---

ʻ for the taking of a forward ſound. Whereas in a hare, which ʻ is very quick of hearing, and thinks of nothing but being purʻ ſued, it is ſupplied with a bony tube, which, as a natural otoʻ couſtic, is ſo directed backward, as to receive the ſmalleſt and ʻ moſt diſtant ſound that comes behind her. Grew's Coſmolog. Sacr. l. 1. c. 5. ſect. 6.

[h] The texture of the tragus and antitragus is ſofter than that of the helix, which ſerveth gently to blunt, not forcibly to repel, the ſound in the concha.

'in the hearing, with a certain murmur, or 'ſwooing, like the fall of waters[i].'

ANOTHER wiſe proviſion of the Creator, is in the ſubſtance of the outward ear, which is cartilaginous, the fitteſt for this place. For, as an ingenious, anatomiſt[k], obſerves. 'If it had 'been bone, it would have been troubleſome, 'and might, by many accidents, have been 'broken off: if fleſh, it would have been ſubject to contuſion.' But indeed a worſe conſequence than this would have enſued ſuch a ſoftneſs as that of fleſh, and that is, it would neither have remained expanded, neither would it ſo kindly receive and circulate the ſounds, but abſorb, retard, or blunt their progreſs into the inward organ. But being hard, and curiouſly ſmooth and tortuous, ſounds find an eaſy paſſage,

---

[i] DR. Gibſon's anatomy, chap. 22. book iii.

'Thoſe whoſe ears are cut off, have but a confuſed way of 'hearing, and are obliged either to form a cavity round the 'ear with their own hands, or elſe to make uſe of a horn, and 'apply the end of it to the inner cavity of the ear, in order to 'receive the agitated air. It is likewiſe obſerved, that thoſe whoſe 'ears jut out, hear better than flat-eared perſons.' Monſieur Dionis's Anat. Demonſt. 8.

[k] Gibſon, Ibid.

ſage, with a regular volutation and refraction; as in a well built arch, grotto, or muſical inſtrument, which magnify and meliorate ſounds; and ſome of which convey even a whiſper to a large diſtance[1]: but from the outward, let us carry our ſurvey,

2. To the inward part of this admirable organ. And here we find the moſt curious and

---

[1] It would nauſeate the reader to reckon up the places famed for the conveyance of whiſpers, ſuch as the priſon of Dionyſius at Syracuſe, which is ſaid to increaſe a whiſper to a noiſe; the clapping one's hands to the ſound of a cannon, &c. Nor the Aqueducts of Claudius, which carry a voice ſixteen miles, and many others both ancient and modern. If the reader hath a mind to be entertained in this way, he may find enough in Kircher's Phonurgia. But it may not be irkſome to mention one or two of our own in England. Among which, one of the moſt famed is the whiſpering-place in Glouceſter-cathedral, which is no other than a gallery above the eaſt end of the choir, leading from one ſide thereof to the other. It conſiſteth, if I miſtake not, of five angles, and ſix ſides, the middlemoſt of which is a naked, uncovered window, looking into a chapel behind it. I gueſs the two whiſperers ſtand at about twenty-five yards diſtance from one another. But the dome of St. Paul's London, is a more conſiderable whiſpering-place, where the ticking of a watch, when no noiſe is in the ſtreets, may be heard from ſide to ſide; yea, a whiſper may be ſent all round the dome. And not only in the gallery below, but above, upon the ſcaffold, I tried, and found that a whiſper would be carried over one's head round the top of the arch, notwithſtanding there is a large opening in the middle of it, into the upper part of the dome.

artful proviſion for every emergency and occaſion. The auditory paſſage, in the firſt place, curiouſly tunneled, and artfully turned, to give ſounds an eaſy paſſage, as well as a gentle circulation and refraction; but withal, ſo as to prevent their too furious ruſhing in, and aſſaulting the more tender parts within.

And foraſmuch as it is neceſſary that this paſſage ſhould be always open, to be upon the watch [m]; therefore to prevent the invaſion of noxious inſects, or other animals (who are apt to make their retreat in every little hole) nature hath ſecured this paſſage [n], with a bitter nauſeous ex-

---

[m] 'Auditus autem ſemper patet; ejus enim ſenſu etiam dormientes egemus: a quo cum ſonus eſt acceptus, etiam e ſomno excitamur. Flexuoſum iter habet, ne quid intrare poſſit, ſi ſimplex, et directum pateret; proviſum etiam, ut ſiqua minima beſtiola conaretur irrumpere, in ſordibus aurium, tanquam in viſco, inhæreſceret.' Cic. de Nat. Deor. l. 2. c. 57.

It deſerves a particular remark here, that in infants in the womb, and newly born, the meatus auditorius is ſhut up very cloſely, partly by the conſtriction of the paſſage, and partly by a glutinous ſubſtance, whereby the tympanum is guarded againſt the water in the ſecundine, and againſt the injuries of the air as ſoon as the infant is born.

[n] It is remarkable, that in moſt, if not all animals, whoſe ears are tunneled, or where the meatus auditorius is long enough to afford harbour to ear-wigs, or other, inſects; that, I ſay, in th

excrement [o], afforded from the glands [p] appointed for that purpoſe.

FROM hence let us approach the moſt inward parts

---

the ears of ſuch, ear-wax is conſtantly to be found. But in birds, whoſe ears are covered with feathers, and where the tympanum lies but a little way within the ſkull, no ear-wax is found, becauſe none is neceſſary to the ears ſo well guarded, and ſo little tunneled.

[o] THE ear-wax was thought, by the old anatomiſts, to be an excrement of the brain: 'Humor bilioſus a cerebro expurgatus,' the Bartholines ſay of it, l. 3 c. 9. But as Schelhammer well obſerves, 'Nil abſurdius, quam cerebri excrementum hoc ſtatuere. Nam et ratio nulla ſuadet, ut in cerebro fieri excrementum tale credamus:——neque viæ patent per quas ab eo ſecluſum in meatum auditorium poſſit inde penetrare.' As to its taſte, Caſſerius gives inſtances of its being ſweet in ſome creatures. But Schelhammer ſays, 'Ego vero ſemper, cum amaritie aliquid dulcedinis in illo deprehendi.' Vide Schel. de Audit. p. 1. c. 4. ſect. 10. But I could never diſtinguiſh any ſweetneſs in it; but think it inſipid mixed with a bitterneſs.

[p] 'Cerumina amara arteriolis exudantia.' Willis de Anim. Brut. par. 1. c. 14. 'In the ſkin—are little glands, which furniſh a yellow and bitter humour. Monſieur Dionis's Dem. 18. An handſone cut of thoſe glandulæ ceruminoſæ is in Dr. Drake, from Valſalva.

Pliny attributes a great virtue to the ear-wax; Morſus hominis inter aſperrimos numeratur: medentur ſordes ex auribus: ac ne quis miretur, etiam ſcorpionum ictibus ſerpentiumque ſtatim impoſitæ.' Plin. Nat. Hiſt. l. 28. c. 4. And that it hath an healing quality, and may be accounted a good balſam, I myſelf have experienced.

parts, in which we ſhall ſee ſtrokes of the moſt exquiſite art. To paſs over the innate air, that moſt authors talk of [q], becauſe there is no ſuch, the paſſage to the palate [r], and their uſes, with divers other curious things that might be named; let us ſtop a little at the part containing the reſt, namely

---

[q] That there is ſuch a thing as the innate air, talked of much by moſt authors on this ſubject, Schelhammer very juſtly, I think, denies; by reaſon there is a paſſage into the inner ear, from the throat, through with the innate air may paſs out, and the outward air enter in. Vide Par. Alt. p. 2. c. 1. ſect. 10. When by ſtopping our breath, and ſtraining, we force the external air into the ear, it may be heard ruſhing in; and if much be forced in, it may be felt alſo to beat againſt the tympanum. When the paſſage to the throat is by any means ſtopped, as by a cold in the head, &c. the hearing thereby becomes dull and blunt; by reaſon the communication between the outward and inward air is obſtructed: but when by ſtrong ſwallowing, or ſuch like motion of the throat, the paſſage is opened, we perceive it by a ſudden ſmack or crack, and we immediately hear very clearly; the load of feculent air being at that time diſcharged from the inner ear.

It is a wiſe proviſion, that the paſſage for the air into the ear, is from the throat; 'Ut non ſtatim quivis aer externus irrumpere 'queat (as Schelhammer ſaith, par. ult. cap. 4. ſect. 8.) ſed nonnihil 'immutatus, ac temperatus, calore ex medio ventre expirante; imo 'fortaſſis non facile alius, niſi ex pulmonibus.

[r] Valſalva hath given us a more accurate deſcription of the tuba Euſtachiana, or paſſage to the palate, than any other author; to whom I therefore refer, De Aur. Human. c. 2. ſect. 16, etc.

The chief uſe hereof, he thinks, is to give way to the inner air, upon every motion of the membrana tympani, the malleus, incus namely, the bone [f]. The particular texture and hardneſs of which, above other bones of the body, is very remarkable; whereby it ſerves not only as a ſubſtantial guard to the ſenſory, but alſo to oppoſe the impulſes of the etherial matter, that there may be no loſs nor confuſion in the ſound; but that it may be conveyed regularly and intirely to the auditory nerves.

The next part I ſhall take notice of, may be that fine membrane called the tympanum, or membrana tympani [t]; with its inner membrane

---

incus, and ſtapes. This paſſage, if it be ſhut up, deafneſs enſues: of which he gives two inſtances; one a gentleman, who loſt his hearing by a polypus in the noſe reaching to the uvula; the other a yeoman, labouring with an ulcer above the left ſide of the uvula; which when he ſtopt with a tent dipped in medicine, he loſt his hearing in the left ear, and recovered it, as ſoon as the tent was out. Ibid. cap. 5. ſect. 10.

[f] 'Os [petroſum] ex quo interiores [labyrinthi] cavitatum 'parietes conflati ſunt, album duriſſimum, necnon maxime com'pactum. Id autem a natura ita comparatum eſſe videtur, ut 'materia ætherea ſonorum objectorum impreſſionibus onuſta, dum 'prædictis impingitur parietibus, nihil aut ſaltem fere nihil motus 'ſui amittat, atque adeo illum qualem ab objectis ſonoris accepit, 'talem communicet ſpiritui animali contento intra expanſiones 'rami mollioris nervorum auris.' Dr. Ram. Vieuſſens of Montpelier, in Phil, Tranſ. No 258.

[t] The tympanum of the ear, or as Valſalva and the moderns, the membrani tympani, was taken notice of as early as Hippocrates's

brane [u]; together with the four little appendant bones [v], and the three inner muſcles to move them, and adjuſt the whole compages to the ſeveral purpoſes of

crates's time. In birds, it is ſtrained towards the outward parts; in other animals towards the brain, or inner parts. Monſieur Dionis ſaith, 'It is not equally faſtened to the whole circumference of the bony circle, in which it is inchaſed; for on the upper ſide it hath a free diſengaged part, by which ſome can give vent to the ſmoke in their mouth.' Demon. 8. That there is ſome paſſage I doubt not, but I queſtion whether Monſieur Dionis ever ſaw the diſengaged part he mentions. I have myſelf carefully ſearched divers ſubjects, and do not remember to have ſeen any ſuch paſſage; and I perceive it eſcaped the diligent Schelhammer's eye. Valſalva alſo, by injecting in through the tuba Euſtachiana, could not force any liquor into the meatus auditorius; but yet he imagines he found the paſſage out in another place of the drum, in ſome morbid, and one ſound head. Valſalv. de. Aur. Hum. cap. 2 ſect. 8. Mr. Cowper alſo affirms there is a paſſage by the upper part of the membrane. Anat. Ap. fig. 8.

[u] Dr. Vieuſſens, before-named, diſcovered a membrane, 'tenuiſſimæ raræque admodum texturæ intra cavitatem tympani;' as he deſcribes it. Whoſe uſe he ſaith is, 1. 'Occludens labyrinthi januam impedit ne naturalis puriſſimus ac ſubtiliſſimus aer intra cavitates—communicationem—habeat cum aere craſſo. 2. Labyrinthi baſin calefacit, etc. ubi ſupra.' Probably this double membrane may be ſuch, or after the ſame manner as it is in the tympanum of birds: of which ſee my obſervations in book vii. chap. 2.

[v] The four little bones being treated of by all that have concerned themſelves about this ſenſe of hearing, ſince their diſcovery, I ſhall take notice of only two things concerning them. 1. The diſcovery of them is owing wholly to the diligence and ſagacity of the latter ages; of which Schelhammer gives this account from Fallopius: 'Hæc oſſicula antiquis anatomicis——ignota fuere; primuſque qui in

of hearing, to hear all manner of ſounds, loud or languid, harſh or grateful [w].

From

‘ in lucem produxit [malleum et incudem] fuit Jac. Carpenſis; primus quoque procul omni dubio anatomicæ artis, quam Veſalius poſtea perfecit, reſtaurator. Tertium ſtapedam] invenit ac promulgavit primus Joh. Phil. ab Ingraſſia, Siculus, philoſophus, ac medicus doctiſſimus. Quartum, Thoma Bartholino teſte, viro longe celeberrimo, Fran. Sylvio debetur.’ Schel. ubi ſupra. Cap. 3. ſect. 9. 2. Their difference in animals: in man and quadrupeds, they are four, curiouſly inarticulated with one another; with an external and internal muſcle to draw, or work them, in extending, or relaxing the drum; but in fowls the caſe is very different: ‘ His unum oſſiculum ſolum largita eſt natura, quod mobilis, quæ in tympanum videtur terminari. Id. ib. ſect. 8. Collumellam forte appellaveris: teres enim eſt et ſubtiliſſimum, baſi innitens latiori, rotundæ. Huic adnexa eſt cartilago valde [mobilis].’ ‘ In the ears of all the fowls that I could examine, I never found any more than one bone, and a cartilage making a joint with it, that was eaſily moveable. The cartilage had generally an epiphyſe, or two, one on each ſide——The bone was very hard and ſmall, having at the end of it a broad plate, of the ſame ſubſtance, very thin, upon which it reſted as on its baſis.’ Dr. Al. Moulen in Phil. Tranſ. No 100.

Theſe are the moſt material things I find obſerved by others, concerning the ears of fowls, and ſome of them hardly, I believe, obſerved before. To which I ſhall ſubjoin ſome other things I have myſelf diſcovered, that I preſume eſcaped the eyes of thoſe moſt curious and inquſitive anatomiſts. Of which ſee the laſt cited book vii. chap. 2.

[w] ‘ Videtur quod tympanum auditionis inſtrumentum præliminare et quaſi præparatorium fuerit, quod ſoni impreſſionem, ſive ſpecies ſenſibiles primo ſuſcipiens, eas in debita proportione, et apta conformitate verſus ſenſorium, quod adhuc interius ſitum eſt, dirigat: ſimili officio fungitur reſpectu auditus, ac tunicæ oculi pupillam conſtituentes, reſpectu viſus; utræque membranæ ſpecies

ſenſibiles

From this region of the tympanum, I might paſs

' ſenſibiles refringunt et quaſi emolliunt, eaſque ſenſorio non niſi
' proportionatas tradunt, cui nudo ſi adveniant, teneriorem ejus
' craſin facile lædant, aut obruant. Revera tympanum non audit,
' ſed meliori tutiorique auditioni confert. Si hæc pars deſtruatur,
' ſenſio adhuc aliquamdiu, rudi licet modo, peragi poſſit; quippe
' experimento olim in cane facto, etc.—Janitoris officio ut tymp-
' num recte defungi poſſit, expanſum ejus pro data occaſione
' ſtringi, aut relaxari debet, veluti nimirum oculi pupilla—Qua-
' propter huic auris tympano, non ſecus ac bellico, machinæ ſive
' tæniæ quædam apponuntur, quæ ſuperficiem ejus modo ten-
' ſiorem, modo laxiorem reddant: hoc enim efficiunt tria oſſicula,
' cum muſculo,' etc: Willis de An. Brut. c. 14.

For this opinion of Dr. Willis, Dr. Schelhammer is very ſevere upon him, deriding the refractions he ſpeaks of; and therefore ſeriouſly proves, that they are the humours, not tunics of the eye, that refract the rays of light; and then jeeringly demandeth, whether the ſonorous rays are refracted by paſſing through a different medium? whether the convexity or concavity of the drum collects thoſe rays into a focal point, or ſcatters them? etc. And then ſaith, 'Ob has rationes a clariſſ. viri, ac de re medica praeclare
' meriti, ſententia non poſſumus non eſſe alieniore; in quo uti
' ingenium admiror, quoties medicamentorum vires, aut morborum
' cauſas explicat, ſic ubi forum ſuum egreſſus, philoſophum agit,
' ac vel partium uſum, vel chymicarum rerum naturam ſcrutetur,
' ejus haud ſemel non modo judicium deſidero, verum aliquando
' etiam fidem.' This is ſo ſevere and unjuſt a cenſure of our truly famous countryman, a man of known probity, that might deſerve a better anſwer; but I have only time to ſay, that although Dr. Schelhammer hath out-done all that wrote before him, in his book de Auditu, and ſhewed himſelf a man of learning and induſtry; yet as our countryman wrote more than he, though perhaps not free from errors too, ſo he hath manifeſted himſelf to have been as curious and ſagacious an anatomiſt, as great a philoſopher, and as learned and ſkilful a phyſician, as any of his cenſurers, and his reputation for veracity and integrity, was no leſs than any of theirs

too. But after all this terrible clamour, Dr. Schelhammer prejudicately miſtaketh Dr. Willis's meaning, to ſay no worſe. For, by 'utræque membranæ refringunt,' Dr. Willis plainly enough, I think, means no more than a reſtriction of the ingreſs of too many rays; as his following explicatory words manifeſt, viz. 'refringunt, et quaſi emolliunt, eaſque ſenſorio non niſi proportionatas tradunt.' But indeed Dr. Schelhammer hath ſhewn himſelf a too rigid cenſor, by making Dr. Willis ſay, the ear-drum hath ſuch like braces as the war-drum, viz. 'Quod porro de machinis ſeu tæniis tympani bellici adducit, dicitque idem in tympano auditorio conſpici, id prorſus falſiſſimum eſt.' I wonder Dr. Schellhammer did not alſo charge Dr. Willis with making it a porter, ſince he hath in the ſame paragraph, 'janitoris officio,' etc. But Dr. Willis's meaning is plain enoungh, that the little bones and muſcles of the ear-drum do the ſame office in ſtraining and relaxing it, as the braces of the war-drum do in that. And conſidering how curious and ſolemn an apparatus there is of bones, muſcles, and joints, all adapted to a ready motion, I am clearly of Dr. Willis's opinion, that one great uſe of the ear-drum is for the proportioning ſounds; and that by its extenſion and refraction, it correſponds to all ſounds, loud or languid, as the pupil of the eye doth to ſeveral degrees of light: and that they are no other than ſecondary uſes aſſigned by Dr. Schelhammer, as the principal or ſole uſes of keeping out the external colder air, duſt, and other annoyances? but eſpecially that, 'Obſolius aeris interni potiſſimum irrumpentis vim, hunc motum tympani ac mallei eſſe conditum, ut cedere primum, deinde ſibi reſtitui queat:' as his words are, p. ult. c. 6. ſect. 13.

IT was no improbable thought of Rohault, 'Nos attentos præbere, nil aliud eſt, niſi tympanum, ubi ita opus eſt facto, contendere aut laxare, et operam dare ut illud in ea poſitione intentum ſtet, in qua tremulum aeris externi motum commodiſſime excipere poſſit.' Roh. Phyſ. p. 1. c. 26. ſect. 48.

The hearing of deaf perſons more eaſily by means of loud noiſes, is another argument of the uſe of the ſtraining or relaxation of the tympanum in hearing. Thus Dr. Willis, 'ubi ſupra,

'Accepi olim a viro fide digno, ſe mulierem noviſſe, quæ licet, 'ſurda fuerit, quouſque tamen intra conclave tympanum pulſaretur, verba quævis clare audiebat: quare maritus ejus tympaniſtam pro ſervo domeſtico conducebat, ut illius ope, colloquia interdum cum uxore ſua haberet, Etiam de alio ſurdaſtro mihi narratum eſt, qui prope Campanile degens, quoties una plures Campanæ reſonarent, vocem quamvis facile audire et non alias potuit.'

'Abſciſſo muſculo [proceſſus majoris mallei] in recenti aure, relaxatur [tympani membrana].' Valſa. de Aur. Hum. c. 2. ſect. 5.

Upon conſidering the great difference in authors opinions, about the uſe of the parts, and manner how hearing is performed, as alſo what a curious proviſion there is made in the ear, by the four little bones, the muſces, membrane, &c. I was minded, ſince I penned this note, to make inquiry myſelf into this part, and not to rely upon authority. And after a diligent ſearch of various ſubjects, I find we may give as rational and eaſy an account of hearing, as of ſeeing, or any other ſenſe; as I have ſhewn in my laſt cited note book vii. chap. 2. with relation to birds. And as to men and beaſts, the caſe is the ſame, but the apparatus more complex and magnificent. For whereas in birds, the auditory nerve is affected by the impreſſions made on the membrane, by only the intermediacy of the columella; in man, it is done by intervention of the four little bones, with the muſcles acting upon them; his hearing being to be adjuſted to all kinds of ſounds, or impreſſions made upon the membrana tympani. Which impreſſions are imparted to the auditory nerve, in this manner, viz. firſt they act upon the membrane and malleus, the malleus upon the incus, and the incus upon the os orbiculare and ſtapes; and the ſtapes upon the auditory nerve: for the baſe of the ſtapes (the ſame as the operculum in birds) not only covers the feneſtra ovalis, within which the auditory nerve lieth, but hath a part of the auditory nerve ſpread upon it too. It is manifeſt that this is the true proceſs of hearing; becauſe if the membrane be moved, you may ſee all the bones to that of the labyrinth [x], and therein ſurvey the curious and admirable ſtructure of the veſtibulum, the ſemicircular canals, [y] and cochlea; particularly the artificial gyrations, and other ſingular curioſities obſervable in the two latter.

---

move at the ſame time, and work the baſe of the ſtapes up and down in the feneſtra ovalis, as I ſhewed in this chapter, concerning the mole; and as it may be ſeen in other ears carefully opened, if the parts remain in ſitu.

[x] I do not confine the labyrinth to the canales ſemicirculares, or any other part, as the elder anatomiſts ſeem to have done, who by their erroneous and blind deſcriptions ſeem not well to have underſtood theſe parts; but with thoſe much more curious and accurate anatomiſts, monſieur de Verney, and Dr. Valſalva; under the labyrinth, I comprehend the canales ſemicirculares, and the cochlea, together with the intermediate cavity, called by them the veſtibulum.

[y] In the ſemicircular canals, two things deſerve to be noted. 1. That the three canals are of three different ſizes, major, minor, and minimus. 2. Although in different ſubjects they are frequently different; yet in the ſame ſubject they are conſtantly the ſame. The reaſon of all which, together with the uſes, Valſalva ingeniouſly thinks is, that as a part of the tender auditory nerve is lodged in theſe canals, ſo they are of three ſizes, the better to ſuit all the variety of tones; ſome of the canals ſuiting ſome, and others, other tones. And although there be ſome difference as to the length and ſize of theſe canals, in different perſons; yet leſt there ſhould be any diſcord in the auditory organs of one and the ſame man, theſe canals are always in exact conformity to one another in one and the ſame man. Vide Valſal. ubi ſupra, cap. 3. ſect. 7. and cap. 6. ſect. 4, 9.

But I ſhall not expatiate on theſe recluſe parts; only there is one ſpecial contrivance of the nerves miniſtering to this ſenſe of hearing, which muſt not be paſſed by; and that is, the branches of one of the auditory nerves[z], ſpread partly to the muſcles of the ear, partly to the eye, partly to the tongue and inſtruments of ſpeech, and inoſculated with the nerves to go to the heart and breaſt, by which, means there is an admirable and uſeful conſent between theſe parts of the body; it being natural for moſt animals, upon the hearing any uncouth ſound, to erect their ears, and prepare them to catch every ſound; to open their eyes (thoſe conſtant faithful centinels) to ſtand upon their watch; and to be ready with the mouth to call out, or utter what the preſent occaſion ſhall dictate. And accordingly it is very uſual for moſt animals, when ſurprized, and terrified with any noiſe, preſently to ſhriek and cry out.

---

[z] ‘ Hic poſterior nervus extra cranium delatus in tres ramos dividitur, qui omnes moribus patheticis—inſerviunt. Primus—muſculis auris impenditur. Procul dubio hujus actione efficitur ut animalia quævis a ſubito ſoni impulſu, aures quaſi ſonum nimis cito tranſeuntem capturas erigant. Ramus alter—verſus utrumque oculi angulum ſurculos emittit: qui muſculis palpebrarum attollentibus inſeruntur; quorum certe munus eſt ad ſubitum ſoni appulſum oculos confeſtim aperire, eoſque velut ad excubias vocare—Tertius—ramus verſus linguæ radicem deſcendens, muſculis ejus et oſſis hyoeideos diſtribuitur, adeoque organa quædam vocis edendæ actuat.’ &c. Wil. Cer, An. 2. c. 17.

BUT there is beſides this, in man, another great uſe of this nervous commerce between the ear and the mouth; and that is, as one of 'the beſt authors on this ſubject expreſſeth it[a]. 'That the voice may correſpond with the hearing, 'and be a kind of echo thereof, that what is 'heard with one of the two nerves, may be 'readily expreſſed with the voice, by the help of 'the other.'

Thus much may ſuffice to be ſaid concerning the organ. Let us,

II. Take notice of the object of this admirable ſenſe, namely, ſound; and ſo conclude this chapter. I ſhall not here inquire into the nature and properties of ſound, which is in a great meaſure intricate, and hath puzzled the beſt naturaliſts: neither will I ſhew how this admirable effect of the divine contrivance may be improved to divers uſes [b] and purpoſes in human life; but my buſineſs will be to ſhew that this thing, of ſo admirable uſe in the animal world, is the work of God. And this will appear, let the ſubject matter of ſounds be what it will; either

---

[a] 'Hujuſmodi nervorum conformatio in homine uſum alium 'inſigniorem præſtat, nempe ut vox,' &c. Willis, ibid.

[b] AMONG the uſes to which the wit of man hath employed ſounds, we may reckon the inſtruments uſeful in convocating aſ-

ſemblies, managing armies, and many other occaſions, wherein bells, trumpets, drums, horns, and other ſounding inſtruments are uſed; the particulars of which it would be tedious to recount: as that the biggeſt bell in Europe is reckoned to be at Erfurt in Germany, which they ſay may be heard twenty-four miles; with much more to the ſame purpoſe. I ſhall therefore only for a ſample take notice of the ſpeaking-trumpet; the invention of which is commonly aſcribed to our eminent Sir Samuel Morland; but was more probably Ath. Kircher's; at leaſt he had contrived ſuch an inſtrument, before Sir Samuel hit upon his. Kircher in his Phonurg, ſaith, the Tromba publiſhed laſt year in England, he had invented twenty four years before, and publiſhed in his Miſurgia; that Jac. Albanus Ghibbeſius, and Fr. Eſchinardus aſcribe it to him; and that G. Schottus teſtifieth he had ſuch an inſtrument in his chamber in the Roman College, with which he could call to, and receive anſwers from the porter. And conſidering how famed Alexander the Great's tube was, which is ſaid might be heard 100 ſtadia, it is ſomewhat ſtrange that no body ſooner hit upon the invention. Of this Stentorophonic horn of Alexander, there is a figure preſerved in the Vatican, which, for curioſity ſake, I have from Kircher repreſented in fig. 3. He ſaith its diameter was five cubits, and that it was ſuſpended on a ſupporter.

For the make of the ſpeaking-trumpet, and the reaſon why it magnifies ſounds, I ſhall refer to Kircher; eſpecially to Sir Samuel Morland's Tuba Stentorophonica, publiſhed in 1672.

Kircher ſaith, he took one of theſe trumpets of fifteen palms length, along with him to the mons Euſtachianus, where he convocated 2200 perſons to prayers, by means of the unuſual ſound, at two, three, four, and five Italian miles diſtance.

With

ther the atmoſphere [c] in groſs, or the ætherial part thereof, or ſoniferous particles of bodies, as ſome fancy,

---

With theſe bellowing-trumpets, I ſhall join ſome bellowing-caves for the readers diverſion. Ol. Magnus deſcribes a cave in Finland, near Viburgh, called Smellen, into which, if a dog, or other living creature be caſt, it ſends forth ſo dreadful a ſound, that knocks down every one near it. For which reaſon they have guarded the cave with high walls, to prevent the miſchiefs of its noiſe Vide. Ol. Magn. Hiſt. l. 11. c. 4. Such another Peter Martyr ſaith is in Hiſpaniola, which with a ſmall weight caſt into it, endangers deafneſs at five miles diſtance. And in Switzerland Kircher ſaith, in the Cucumer-Mountains is a pit that ſends out both a dreadful noiſe and a great wind therewith; and that there is a well in his country 3000 palms deep, whoſe ſound is equal to that of a great gun. Vide Kirch. Phonurg.

Ol. Magnus ſpeaking of the vaſt high mountains of a northern province, called Angermannia, ſaith, 'Ubi baſes eorum in profundiſſimo gurgite ſtantes, caſu aliquo, vel propoſito nautæ acceſſerint, tantum horrorem ex alta fluctuum colliſione percipiunt, ut niſi præcipiti remigio, aut valido vento evaſerit, ſolo pavore fere exanimes fiant, multoque dierum curriculo, ob capitis turbationem, priſtinæ mentis, et ſanitatis compotes vix evadant. Habent baſes illorum montium in fluctuum ingreſſu et regreſſu tortuoſas rimas, ſive ſciſſuras, ſatis ſtupendo naturæ opificio fabricatas, in quibus longa voragine formidabilis ille ſonitus quaſi ſubterraneum tonitru generatur.' Ol. Magn. l. 2. c. 4. See alſo chap. 19.

[c] That the air is the ſubject, or medium of ſound, is manifeſt from the experiments in rarified and condenſed air. In an unexhauſted receiver, a ſmall bell may be heard at the diſtance of ſome paces: but when exhauſted, it can ſcarce be heard at the neareſt diſtance: and if the air be compreſſed, the ſound will be louder, proportionably to the compreſſion or quantity of

fancy, or whatever elſe the philoſophers may think it. For, who but an intelligent being,

what

---

air crowded in, as I have often tried myſelf, and may be ſeen in Mr. Hawkſbee's curious experiments, p. 97. Alſo his experiments in Phil. Tranſ. No 321.

Neither doth this ſucceed only in forced rarefactions and condenſations of the air, but in ſuch alſo as are natural; as is evident from David Froedlichius in Varenius, upon the higheſt eminences of Carpathus, near Keſmerckt in Hungary. The ſtory of Froedlichius is this, 'Ego menſe Junii 1615, tum adoleſcens, ſublimitatem horum montium, cum duobus comitibus ſcholaribus, experiri, volens, ubi, cum in primæ rupis verticem, magno labore, me ſummum terminum aſſecutum eſſe putarem, demum ſeſe obtulit alia multo altior cautes, ubi per vaſta eaque vacillantia ſaxa (quorum unum, ſi loco a viatore dimovetur —aliquot centena—rapit, et quidem tanto cum fragore, ut illi metuendum ſit ne totus mons corruat, eumque obruat) enixus eſſem, iterum alia ſublimior prodiit, &c. donec ſummo vitæ periculo ad ſupremum cacumen penetraverim. Ex declivioribus montibus cum in ſubjectas valles,—nil niſi obſcuram noctem, aut cœruleum quid, inſtar profundi aeris, quod vulgo ſudum cœlum appellatur, obſervare potui mihique videbar, ſi de monte caderem, non in terram, ſed recte in ſolem me prolapſurum. Nimia enim declivitate, ſpecies viſibiles extenuatæ et hebetatæ fuerunt. Cum vero altiorem montem peterem, quaſi intra nebulas denſiſſimas hærebam—Et cum non procul a ſummo vertice eſſem, de ſublimi quieſcens proſpexi et animadverti iis in locis, ubi mihi antea videbar intra nebulas hæſiſſe, compactas atque albas ſeſe movere nubes ſupra quas, per aliquot milliaria et ultra terminos Sepuſi commodus mihi proſpectus patuit. Alias tamen etiam nubes altiores, alias item humiliores, necnon quaſdam æqualiter a terra diſtantes vidi. Atque hinc tria intellexi. 1. Me tum tranſiviſſe principium mediæ æris regionis. 2. Diſtantiam nubium a terra, non eſſe æqualem—3. Diſtantiam nubium—non 12 mill. Ger. ut quidam——ſed tantum di-

midi-what leſs than an omnipotent and infinitely wiſe God could contrive, and make ſuch a fine body, ſuch a medium, ſo ſuſceptible of every impreſſion, that the ſenſe of hearing hath occaſion for, to empower all animals to expreſs their ſenſe and meaning to others; to make known their fears their wants, their pains, and ſorrows in melancholic tones; their joys and pleaſures in more harmonious notes; to ſend their minds at great diſ-

tances

‘ midiatum mill. Ger. In ſummum montis verticem cum perveniſſem, adeo tranquillum et ſubtilem aerem ibi offendi, ut ne pili quidem motum ſentirem, cum tamen in depreſſioribus ventum vehementem expertus ſim: unde collegi ſummum cacumen iſtius montis Carpathici ad mill. Germ. a radicibus ſuis imis exſurgere, et ad ſupremam uſque aeris regionem, ad quam venti non aſcendunt, pertingere. Exploſi in ea ſummitate ſclopetum: quod non majorem ſonitum primo præ ſe tulit, quam ſi tigillum vel bacilum confregiſſem; poſt intervallum autem temporis murmur prolixum invaluit, inferioreſque montis partes, convalles et ſylvas opplevit. Deſcendendo per nives annoſas intra convalles, cum iterum ſclopetum exonerarem, major et horribilior fragor, quam ex tormento capaciſſimo inde exoriebatur: hinc verebar ne totus mons concuſſus mecum corrueret· duravitque hic ſonus per ſemiquadrantem horæ, uſque dum abſtruſiſſimas cavernas pentraſſet, ad quas aer undique multiplicatus reſiliit.—In his celſis montibus, plerumque ningit grandinatve media æſtate, quoties nempe in ſubjecta et vicina plantitie pluit, uti hoc ipſum expertus ſum. Nives diverſorum annorum ex colore et cortice duriore dignoſci poſſunt.’ Varen. Geogr. l. 1. c. 19. prop. ult.

THE ſtory being diverting, and containing diverſe things remarkable, I have choſen to note the whole of it, although ſomewhat long, rather than ſingle out the paſſages only which relate tances [d], in a ſhort time [e], in loud boations; or

to

---

to the diminiſhing the ſound of his piſtol, by the rarity of the air at that great aſcent into the atmoſphere; and the magnifying the ſound by the polyphoniſms or repercuſſions of the rocks, caverns, and other phonocamptic objects below in the mount.

But it is not the air alone that is capable of the impreſſions of ſound, but the water alſo, as is manifeſt by ſtriking a bell under water, the ſound of which may plainly enough be heard, but it is much duller, and not ſo loud; and it is alſo a fourth deeper, by the ear of ſome great judges in muſical notes, who gave me their judgements in the matter. But Merſenne ſaith, a ſound made under water, is of the ſame tone or note, if heard under water; as are alſo ſounds made in the air, when heard under water. Vide Merſen. Hydraul.

Having mentioned the hearing of ſounds under water, there is another curioſity worth mentioning, that alſo farther proves water to be ſuſceptible of the impreſſions of ſound, viz. divers at the bottom of the ſea can hear the noiſes made above, only confuſedly. But, on the contrary, thoſe above cannot hear the divers below. Of which an experiment was made, that, had like to have been fatal; one of the divers blew an horn in his diving-bell, at the bottom of the ſea; the ſound whereof, in that compreſſed air, was ſo very loud and irkſome, that ſtunned the diver, and made him ſo giddy, that he had like to have dropt out of his bell, and to have been drowned. Vide Sturmii Colleg. Cur. vol. 2, tentam. 1.

[d] As to the diſtance to which ſound may be ſent, having ſome doubt, whether there was any difference between the northern and ſouthern parts, by the favour of my learned and illuſtrious friend Sir Henry Newton, her late majeſty's envoy at Florence, I procured ſome experiments to be made for me in Italy. His moſt ſerene highneſs the great duke was pleaſed to order great

guns

to expreſs their thoughts near at hand with a
gentle

guns to be fired for this purpoſe at Florence, and perſons were appointed on purpoſe to obſerve them at Leghorn, which they compute is no leſs than 55 miles in a ſtrait line. But notwithſtanding the country between being ſomewhat hilly and woody and the wind alſo was not favouring, only very calm and ſtill, yet the ſound was plainly enough heard. And they tell me, that the Leghorn guns are often heard 66 miles off, at Porto Ferrero; that when the French bombarded Genoa, they heard it near Leghorn, 90 miles diſtant; and in the Meſſina inſurrection, the guns were heard from thence as far as Auguſta and Syracuſe, about 100 Italian miles. Theſe diſtances being ſo conſiderable, give me reaſon to ſuſpect, that ſounds fly as far, or nearly as far in the ſouthern, as in the northern parts of the world, notwithſtanding we have a few inſtances of ſounds reaching farther diſtances. As Dr. Hearn tells us of guns fired at Stockholm in 1685 that were heard 180 Engliſh miles. And in the Dutch war, 1672, the guns were heard above 200 miles. Vide Phil. Thanſ. N° 113. Alſo there is this farther reaſon of ſuſpicion, that the mercury in the barometer riſeth higher without than within the tropics, and the more northerly, ſtill the higher, which may increaſe the ſtrength of ſounds.

“As to the velocity of ſounds by reaſon the moſt celebrated authors differ about it, I made diverſe nice experiments myſelf, with good inſtruments; by which I found, 1. That there is ſome although a ſmall difference, in the velocity of ſounds, with or againſt the wind; which alſo is, 2. Augmented or diminiſhed by the ſtrength or weakneſs of the wind. But that nothing elſe doth accelerate or retard it, not the differences of day or night, heat or cold, ſummer or winter, cloudy or clear, barometer high or low, &c. 3. That all kinds of ſounds have the ſame motion, whether they be loud or languid, of bells, guns, great or ſmall, or any other ſonorous body. 4. That they fly equal ſpaces in equal times. 5thly and laſtly, That the mean of their flight is at the gentle voice, or in ſecret whiſpers! And, to ſay no more, who leſs than the ſame moſt wiſe and indulgent Creator, could form ſuch an oeconomy, as that of melody and muſic is: that the medium ſhould, as I ſaid, ſo readily receive every impreſſion of ſound, and convey the melodious vibration of every muſical ſtring, the harmonious pulſes of every animal voice, and of every muſical pipe; and the ear be as well adapted, and ready to receive all theſe impreſſions, as the medium to convey them: and laſtly, that by means of the curious lodgement, and inoſculation of the auditory nerves before-mentioned, the orgaſms of the ſpirits ſhould be allayed, and perturbations of the mind, in a great meaſure quieted and ſtilled [f]: or, to expreſs it in the words of the laſt cited famous author [g], ‘ That muſic ſhould not only affect ‘ the

---

the rate of a mile in 9 half ſeconds and a quarter, or 1152 feet in one ſecond of time. Vide Phil. Tranſ. ibid.

[f] Timotheus a muſician could excite Alexander the Great to arms with the Phrygian ſound, and allay his fury with another tone, and excite him to merriment. So Ericus king of Denmark, by a certain muſician, could be driven to ſuch a fury, as to kill ſome of his beſt and moſt truſty ſervants. More of this power of muſic over the affections, may be ſeen in Ath. Kirch. Phonurg. lib. 2. ſect. 1. Alſo in Iſ. Voſſius de Poematum cantu et Rythmi viribus.

And

'the fancy with delight, but alſo give relief 'to the grief and ſadneſs of the heart; yea, 'ap-

And not only upon the affections, but alſo on the parts of the body, muſic is able to exert its force, as appears from the Gaſcoigne knight, 'Cui phormingis ſono audito Veſica ſtatim 'ad urinam reddendam vellicabatur.' Such another we have in A° 1. Ephem. Nat. Curioſ. Obſer. 134. Alſo Morhoff de Scyph. vitr. per cert. human. vocis ſonum fracto: where there is not only the account of the Dutchman at Amſterdam, one Nich. Peter, that brake Rummer glaſſes with the ſound of his voice, but alſo divers other inſtances of the powers and effects of ſound. But to the ſtory of the Gaſcoigne knight, Mr. Boyle, from Scaliger, adds a pleaſant paſſage, that one he had diſobliged, to be even with him, cauſed at a feaſt, a bag-pipe to be played, when he was hemmed in with the company; which made the knight bepiſs himſelf, to the great diverſion of all then preſent, as well as confuſion of himſelf. Boyle's Eſſay of the Effect of Lang. Motion. In the ſame book are other matters that may be noted here. One whoſe arm was cut off, was exceedingly tormented with the diſcharge of the great guns at ſea, although he was at a great diſtance on land. And a great ſhip-commander obſerved his wounded men, with broken limbs, ſuffered in like manner at the enemy's diſcharges. An ingenious domeſtic of his own would have his gums bleed at tearing of brown paper. And an ingenious gentleman of Mr. Boyle's acquaintance confeſſed to him, that he was inclined to the knight of Gaſcoigne's diſtemper, upon hearing the noiſe of a tap running. The dancing to certain tunes, of perſons bit with the tarantula, he was aſſured of by an ingenious acquaintance at Tarentum, who ſaw ſeveral, among the reſt a phyſician, affected with that diſtemper. And many other accounts of this kind, ſeemingly credible, are related in Morhoff, Kircher, and many others; although Dr. Cornelio queſtions the matter of fact relating to the cure of the tarantula's bite, in Phil. Tranſ. N° 83. Mr. Boyle alſo ſaith, a ſober muſician told him, he could make a certain woman weep, by playing one tune, which others would be little affected at. And he ſaith, that he himſelf had a kind of ſhivering at repeat-

'appeaſe all thoſe turbulent paſſions, which are excited in the breaſt by an immoderate ferment, and fluctuation of the blood.'

AND now, who can reflect upon all this curious apparatus of the ſenſe of hearing, and

---

ing two verſes in Lucan. And I add, that I very well know one to have a ſort of chill about his præcordia and head, upon reading or hearing the 53d chapter of Iſaiah; as alſo David's lamentations for Saul and Jonathan, 2. Sam. i.

Neither are our own minds and bodies only affected with ſounds but inanimate bodies are ſo alſo. Of which many ſtories may be met with in Kircher particularly a large ſtone that would tremble at the ſound of one particular organ-pipe; in Morhoff alſo, who among many other relations hath this, 'Memini cum ipſi (clariſ. Williſio] de experimento vitri per vocem fracti narrarem, ex eo audiviſſe, quod in ædibus muſicis ſibi vicinis aliquoties collapſum pavimentum fuerit; quod ipſe ſonis contitinuis adſcribere non dubitavit.' Morhoff. c. 12. Merſenne alſo, among many relations in his Harmon. and other books, tells a far more probable ſtory, of a particular part of a pavement, that would ſhake as if the earth would open when the organs played than what he relates about Antipathy, in his Quæſt. Comment. in Geneſ. viz. that the ſound of a drum made of a wolf's ſkin will break another made of ſheep's ſkin: that hens will fly at the ſound of a harp ſtrung with fox-gut-ſtrings, and more to the ſame purpoſe Mr. Boyle alſo, in his laſt cited book tells us, ſeats will tremble at the ſound of organs; and that he hath felt his hat to do ſo too under his hand, at certain notes both of organs, and in diſcourſe; that he tried an arch that would anſwer to c-fa ut, and had done ſo 100 years; and that an experienced builder told him, any well built vault will anſwer ſome determinate note. And at Eaſtbury-houſe near Barking, I myſelf diſcovered the porch, having firm brick-walls, not only to ſound when ſtruck on the bottom, but alſo to give almoſt as loud a ſound when I ſounded the ſame note with my voice,

[g] Willis, ubi ſupra.

not give the great Creator his due praiſe? Who can ſurvey all this admirable work, and not as readily own it to be the work of an omnipotent, and infinitely wiſe and good God [h], as the moſt artful melodies we hear, are the voice or performances of a living creature!

---

[h] 'Ille Deus eſt——qui non calamo tantum cantare, et agreſte, atque inconditum carmen ad aliquam tantum oblectationem modulari docuit, ſed tot artes, tot vocum varietates, tot ſonos, alios ſpiritu noſtro, alios externo cantu edituros commentus eſt.' Senec. de Benef. l. 4. c. 6.

CHAP. IV.

OF THE SENSE OF SMELLING.

THIS ſenſe I ſhall diſpatch in leſs compaſs than the two laſt, becauſe its apparatus (although ſufficiently grand and admirable, yet) is not ſo multiplicious as of the eye and ear; it being ſufficient in this ſenſe, that the odoriferous effluvia of bodies [i] can have an eaſy, free paſſage to the olfactory nerves, without the formalities of refractions, and other preparations neceſſary to the perfection of the two former ſenſes. Accordingly, the all-wiſe Creator hath made ſufficient proviſion for the reception of ſmells by the aperture of the noſtrils[k]: made not of fleſh, or bone, but cartilaginous, the better to be kept open, and withal, to be dilated or contracted, as there is occaſion: for which ſervice it hath ſeveral proper and curious muſcles[l].

---

[i] A piece of ambergreaſe, ſuſpended in a pair of ſcales that would turn with a very ſmall part of a grain, loſt nothing of its weight in three days and a half; neither did aſſafoetida in five days and a half: but an ounce of nutmegs loſt five grains and a half in ſix days; and cloves ſeven grains and four fifths. Boyle's Subtil. of Effluv. c. 5.

AND foraſmuch as it is by breathing[m], that the odorant particles are drawn in, and conveyed to the ſenſory; therefore there is a very wiſe proviſion made in the laminæ, with which the upper part of the noſe is barricaded, which ſerve to two excellent uſes: partly, to fence out any noxious ſubſtances from entering the breathing paſſages in our ſleep, or when we cannot be aware [n]; and partly to receive divarications of the olfactory nerves, which are here thick ſpread, and which do by theſe means meet the ſmells entering with the breath, and ſtriking upon them.

---

[k] 'Nares, eo quod omnis odor ad ſuperiora fertur, recte 'ſurſum ſunt: et quod cibi et potionis judicium magnum earum 'eſt, non ſine cauſa vicinitatem oris ſecutæ ſunt.' Cicer. de Nat. Deor. l. 2. c. 56.

[l] Had not the contriver of animal bodies been minded that his work ſhould have all the ſignatures of accuracy, this ſenſe might have been performed with a bare aperture of the noſe; but that nothing might go imperfect out of his hand, he hath made a part of the noſe eaſily moveable, and given a ſet of muſcles to lift up, and open and ſhut the noſtrils; and ſo adjuſt it to every occaſion of this ſenſe.

[m] 'Odorem non aliud, quam infectum aera, intelligi poſſe. Plin. Nat. Hiſt. l. 9. c. 7

And accordingly, the more accurate this ſenſe is, in any animal, the longer we may obſerve thoſe laminæ are; and more of them in number folded up and crouded together, to contain the more nervous filaments, and to detain and fetter the odoriferous particles in their windings and turnings.

And an admirable proviſion this is, which the great Creator hath made for the good of brute creatures [o]: the chief acts of many of whoſe lives are preformed by the miniſtry of this ſenſe

---

[n] For a further guard againſt the ingreſs of noxious things, the vibriſſæ, or hairs placed at the entrance of the noſtrils ſerve; which, in ſome meaſure, ſtop the entrance of things improper or however, give warning of them; but at the ſame time allow an eaſy paſſage to the breath and odours.

[o] ‘ Multo præclarius emicat [olfactus] in brutis animalibus, ‘ quam in homine: iſte namque hoc ſolo indice, herbarum, ali-

are

of uſe to mankind, which would be otherwiſe of little or no uſe[p]. And moſt of the irrationals, animals, birds, beaſts, and creeping things, do, by their ſmell, find out their food; ſome at great diſtances, and ſome at hand. With what ſagacity do ſome diſcover their food in the midſt of mud and dirt! With what curioſity do the herbaceous kind pick and chuſe ſuch plants as afford them wholeſome food, or ſometimes ſuch as

---

‘orumque corporum prius ignotorum virtutes certiſſime dignoſcunt, quin et victum ſuum abſentem, vel in abſtruſo poſitum, odoratu venantur, ac facillime inveſtigant. Quod autem minus ſagaces ſunt hominum nares, illud non facultatis hujus abuſui, prout non nulli volunt, aſcribi debet verum in cauſa eſt ipſius organi defectus: hoc enim circa victus humani criteria, ubi ratio, et intellectus adſunt, non ita accuratum requiritur: propterea enim inferiores potentiæ in homine, a natura minus perfectæ exiſtunt, ut ſuperiorum cultui et exercitio relinqueretur locus.’ Willis de Anim. Brut. c. 13.

[p] Thus the chief uſe of hounds is to hunt; and other dogs, to be a watch and guard to our houſes by night. For which ſervices, particularly in hounds, their olfactory nerves are not only remarkably larger, like as they are in other brutes; but their branches and filaments are, in the laminæ of the noſtrils, both more and larger than I have ſeen in any other creature whatſoever. Alſo there are more convulſions of the laminæ than I ever remember to have found in any other animal.

The ſagacity of hounds is prodigious; of which ſee an inſtance in book iv. chap. 11.

[q] See book vii. chap. 2. note (*a*), p. 381.

are medicinal [r], and refuſe ſuch as would hurry and deſtroy them! And all by the help principally, if not only, of the ſmell, aſſiſted by its near ally the taſte. Of which I ſhall in the next place ſpeak very briefly.

---

[r] Vide Plin. Hiſt. Nat. l. 8. c. 27. 'Quæ animalia quas 'herbas oſtenderunt.'

CHAP. V.

OF THE TASTE [s].

IN this, as in the laſt ſenſe, we have an apparatus abundantly ſufficient to the ſenſe; nerves curiouſly divaricated about the tongue [t], and mouth, to receive the impreſſions of every guſto; and theſe nerves guarded with a firm and proper tegument to defend them from harms: but withal, ſo perforated in the papillary eminences, as to give a free admiſſion to taſtes.

---

[s] 'Τὰ δὲ εἴδη τῶν χυλῶν, &c. Saporum genera,——dulcis 'pinguis, auſterus, acerbus, acris, ſalſus, amarus, acidus.' Theophr. de Cauſ. Plant. l. 6. c. 1. What may be the cauſe, of the difference of taſtes, he ſaith, is hard to aſſign, πότερον 'γὰρ τοῖς πάθισι, &c. Utrum affectionibus ſenſuum——an figu-'ris, quibus ſinguli conſtant, ut Democritus cenſet, id. ibid. 'Δημόκριτος δὲ, &c. Democritus——dulcem eſſe ſaporem qui 'rotundus; acerbum qui figura; aſperum magna qui multis an-'gulis, &c. id. ib. &c. But of the diverſities and cauſes of taſtes, ſee Dr. Grew. lect. 6. and Dr. Willis de Anim. Brut. c. 12.

[t] 'Intellectus ſaporum eſt cæteris in prima lingua: homini, et in palato.' Plin. l. 11. c 37

But I ſhall ſay no more of this ſenſe; only a word or two of its conſent with the ſmell, and the ſituation of them both: their ſituation is in the moſt convenient place imaginable, for the diſcharge of their offices; at the firſt entrance

[u] in

The opinions of the anatomiſts concerning the organ of taſte, are various. Bauhin. T. Bartholin. Barthalette, Veſlinge, Deuſinge, &c. place it in the laxer, fleſhy parts of the tongue. Our famous Wharton, in the gland at the root of the tongue: Laurentius in the thick tunic covering the tongue; but the learned Malpighi with great probablity concludes, becauſe the outward cover of the tongue is perforated, under which lie papillary parts (of which Mr. Cowper hath very good cuts in his Anat. tab. 13.) that in theſe the taſte lieth. Malpighi'swords are, 'Quare cum dictis meatibus inſignibus occurrant papillaria corpora, probabilius eſt in his ultimis, ex ſubintranti ſapido humore titillationem et medicationem quandam fieri, quæ guſtum efficiat.' Malpig. Op. Tom 2. De Lingua, pag. 18.

'Præcipuum ac fere ſolum Guſtatus organon eſt lingua; cui aliquatenus, ſub obſcure tamen, palatum et ſuperior gulæ pars conſentiunt: in omnibus vero fibræ nervoſæ immediata ſenſationis inſtrumenta ſunt. Quare obſervare eſt, linguam præ alia quavis parte inſigniter fibroſam eſſe, etiam textura valde poroſa conſtare, in eum nempe finem, ut particulæ rei ſapidæ copio-

'ſius

[w] in the way to the grand receptacle of our food and nouriſhment; to ſurvey what is to be admitted therein; to judge between what is wholſome, and fit for nourriſhment, and what is unſavory and pernicious. And for this end, the all-wiſe Creator ſeems to have eſtabliſhed a great conſent between the eye, the noſe and the tongue, by ordering the branches of the ſame nerves [x] to each of thoſe three parts; as alſo indeed, to diverse other parts of the body, which I may have occaſion to mention in a more proper

---

ſus ac penitius intra ſenſorii meatus admittantur—Nervi autem qui fibris linguæ denſiſſime intertextis famulantur, ac ſaporum impreſſiones τῷ πρώτῳ αἰσθητηρίῳ communicant, ſunt——Nervi e paribus tum quinto, tum nono; et ubique cum denſa propaginum ſerie par totum ejus compagem diſtributi.’ Willis ib.

[w] ‘Guſtatus, qui ſentire eorum quibus veſcimus genera debet, habitat in ea parte oris, qua eſculentis potulentis iter natura patefecit. Cic. de Nat. Deor. l. 2 c. 56. Vide quoque ſupra.

[x] ‘Multa hujus [quinti Paris] nervi propagines maſticationis operi deſtinantur: ideoque quoniam alimenta ingerenda non modo guſtus, ſed etiam olfactus et viſus examen ſubire debent, ab eodem nervo, cujus rami ad palatum et fauces miſſi manducationis negotium peragunt, propagines aliæ, velut exploratrices, ad nares et oculos, feruntur, nempe ut iſthæc aliorum ſenſuum organa, etiam ad objecta guſtus melius dignoſcenda probationum auxilliis quibuſdam inſtruantur.’ Will’s Ner. Deſ et Uſus, c. 22.

place [y]. By which means, there is all the guard that can be, againſt pernicious food; foraſmuch as before it is taken into the ſtomach, it is to undergo the trial of three of the ſenſes; the ſcrutiny of the eye, the ſtrict ſurveyor of its outward appearance; and the probation of the ſmell and taſte, the two ſevereſt judges of its natural conſtitution and compoſition.

---

[y] See book v. c. 8.

CHAP. VI.

OF THE SENSE OF FEELING[*].

HAVING ſpent ſo much time upon the other ſenſes, and therein given ſuch ample proofs of the infinite Creator's wiſdom; I ſhall but briefly take notice of two things relating to this laſt ſenſe.

One

---

[*] Malpighi is of this opinion, that as taſte is performed by the papillæ in the tongue, ſo is feeling by ſuch like papillæ under the ſkin. From ſeveral diſſections, and other obſervations he thus concludes, 'Ex his et ſimilibus videbatur animus abunde 'certior redditus, earundem papillarum pyramidalium copiam, 'quas alias in lingua deſcripſi, in locis præcipue exquiſitiori tactui 'dicatis reperiri, eodem progigni nervoſo et cuticulari corpore, 'ſimulque circumvolvi reticulari involucro, et extimam cuticu-'lam, veluti ultimum terminum attingere.——Microſcopio quilibet

'in

One is, its organ and nerves. For, as all ſenſation is performed by the nerves [z]. and indeed the other ſenſes, performed by nerves, are a kind of feeling; ſo is this ſenſe of feeling performed by nerves likewiſe, ſpread in the moſt incomparable, curious manner throughout the whole body. But to deſcribe their origin in the brain, ſpinal marrow, their ramifications to

---

' in manus dorſo pro ſudore orificia quædam miro ordine diſperſa
' intueri poteſt, circa quæ frequentia quædam capitula aſſurgunt;
' hæc vero ſunt papillarum fines, dum a cute aſſurgentes inter-
' poſitum ſuperant rete, ſimulque extimam cuticulam. Haec re-
' petitis ſectionibus deprehendi; ex quibus non improbabiliter de-
' ducam, ſicuti ex elatioribus—papillis——in lingua, guſtus or-
' ganon elicitur——ita ex copioſa harum papillarum congerie——
' in organis, ubi maxime animalia tactus motione afficiuntur,——
' adæquatum tactus organum ſufficienter haberi.' Malpig. de ext.
Tact. Org. p. 26. Conſul quoq; ejuſdem Vit. p. 28.

Theſe obſervations of Malpighi our late curious and diligent Mr. Cowper hath confirmed, and given us very elegant cuts both of the ſkin, and the papillæ, and the nerves, glands, &c. under it, from microſcopical obſervations. Vide Cowper's Anat. Introd. and Tab. 4.

[z] Although the eye be the uſual judge of colours, yet ſome have been able to diſtinguiſh them by their feeling. ' Quidam
' fuit qui venit ad M. Duc. Hetruræ aulam, qui colores per
' tactum cognoſcebat. Pro experimento velum ſericum, unifor-
' miter textum, et pluribus coloribus tinctum; offerebatur, et
' veraciter, de colore in ſingulis partibus judicabat. Grimald de
Lum. et Col. prop. 34. ſect. 59.

all the parts; their inoſculations with one another; and other matters; whereby not only the ſenſe of feeling is performed, but alſo animal motion, and admirable conſent and harmony of the parts of the body is effected, (to deſcribe I ſay, theſe things) would take up too much time, and I have already, and ſhall, as I go along, give ſome hints thereof.

THE other thing I ſhall take notice of, is the diſperſion of this ſenſe throughout the body, both without and within. The other ſenſes, I have obſerved, are ſeated in the very beſt place for the relief and comfort, the guard and benefit of the animal. And foraſmuch as it is neceſſary to the being, and well-being of the body, that every part ſhould be ſenſible of things ſafe, or things prejudicial to itſelf; therefore, it is an admirable contrivance of the great Creator to diſperſe this ſenſe of feeling throughout every part[a]; to diſtinguiſh between pleaſure and pain; things ſalutary, and things hurtful to the body.

THUS

---

[a] ‘ Tactus autem toto corpore æquabiliter fuſus eſt, ut omnes ictus, omneſque nimios et frigoris et caloris appulſus, ſentire poſſimus.’ Cic. ubi ſupra.

‘ Tactus ſenſus omnibus eſt, etiam quibus nullus alius; nam ‘ et oſtreis, et terreſtribus vermibus quoque. Exiſtimaverim omnibus

THUS in the five ſenſes of animals, we have an œconomy worthy of the Creator, and manifeſtly demonſtrating his power, wiſdom, and indulgence. For whether we conſider the mechaniſm of the organs, or the great uſe and convenience of each ſenſe, we find it noble and grand, curious and artificial; and every way worthy of its infinite maker, and beyond the wit and power of any thing but a God, and therefore we muſt even deny our ſenſes, by denying them to be God's handy work.

AND now from thoſe chief machines of animal performances and enjoyments, the five ſenſes; let us paſs to another thing in common to all the ſenſitive creatures, which is reſpiration.

‘ nibus ſenſum et guſtatus eſſe. Cur enim alios alii ſapores ap‘ petunt? in quo vel pracipua naturæ architectio.’ Plin. Nat. Hiſt. l. 10. c. 71.

CHAP. VII.

OF RESPIRATION.

OF all the acts of animal life, this is one of the chief, and moſt neceſſary. For whatſoever hath animal life, hath alſo the faculty of reſpiration, or ſomewhat equivalent thereto [b]. Indeed ſo congenial is this with life, that breath and life are in ſcripture phraſe and common ſpeech taken

---

[b] The uſes aſſigned to reſpiration by all the anatomiſts before Malpighi's diſcoveries of the ſtructure of the lungs, are ſo various, and many of them ſo improbable, that it would be frivolous to recount them. But the more eminent modern anatomiſts aſſign theſe uſes: Willis thus ſums up his opinion, ' Præcipua pulmonum functio, et uſus ſunt, ſanguinem et aerem per totas partium compages, intimoſque receſſus, atque ductus quoſque minutiſſimos traducere, et ubique invicem committere; in eum nempe finem, ut ſanguis venoſus a circuitu redux, et chymo recenti dilutus——tum perfectius miſceatur, et velut ſubigatur, tum potiſſimum ut ſecundum omnes ſuas partes ab aere nitroſo de novo accendatur.' Pharm. p. 2. ſect. 1. c. 2. ſ. 2. Mayow ſaith

taken

ſaith rightly, that one grand uſe of expiration is, 'Ut cum aere 'expulſo, etiam vapores e ſanguine exhalantes, ſimul exſufflen-'tur.' And as for inſpiration that it conveyeth a nitro aerial ferment to the blood, to which the animal ſpirits are owing, and all muſcular motion. Mayow de Reſ. p. 22. &c. mea ed.

Somewhat of the opinion of theſe two laſt cited, if I miſtake not (it being long ſince I read their tracts, and have them not now at my hand) were Ent, Sylvius, Swammerdam, Diemerbroek, and my friend Mr. Ray, in an unpubliſhed tract of his and his letters now in my hands.

But our Dr. Thurſton, for good reaſons, rejects theſe from being principal uſes of reſpiration and thinks, with great reaſon, the principal uſes to be, to move or paſs the blood from the right to the left ventricle of the heart. Upon which account perſons hanged, drowned or ſtrangled by catarrhs, ſo ſuddenly die, namely becauſe the circulation of their blood is ſtopped. For the ſame reaſon alſo it is, that animals die ſo ſoon in the air-pump. Among other proofs he inſtanceth in an experiment of Dr. Croon, Profeſ. Greſh. which he made before our R. S. by ſtrangling a pullet, ſo that not the leaſt ſign of life appeared; but by blowing wind into the lungs through the trachea, and ſo ſetting the lungs a playing, he brought the bird to life again. Another experiment was once tried by Dr. Walter Needham, before Mr. Boyle, and others at Oxford, by hanging a dog ſo that the heart ceaſed moving. But haſtily opening the dog, and blowing wind into the ductus Pecquetianus, he put the blood in motion, and by thar means the heart, and ſo recovered the dog to life again. Vide Thurſton de Reſ. Uſ. p 60. and 63, mea ed.

Such

taken as ſynonymous things, or at leaſt, neceſ-

Such an experiment as Dr. Croon's, my friend, the late juſtly renowned Dr. Hook, ſhewed alſo our Royal Society. He cut away the ribs, diaphragm, and pericardium, of a dog; alſo the top of the wind-pipe that he might tie it on to the noſe of a pair of bellows; and by blowing into the lungs, he reſtored the dog to life; and then ceaſing blowing, the dog would ſoon fall into dying fits; but by blowing again, he recovered; and ſo alternately would die, and recover, for a conſiderable time, as long and often as they pleaſed. Phil. Tranſ, N° 28.

For the farther confirmation of Dr. Thurſton's opinion, the ingenious Dr. Muſgrave cut off, and cloſe ſtopped up the wind-pipe of a dog with a cork, and then threw open the thorax; where he found the blood ſtagnating in the lungs, the arteria pulmonaris, the right ventricle and auricle of the heart, and the two great trunks of the cava, diſtended with blood to an immenſe degree; but at the ſame time, the vena pulmonaris, the left ventricle and auricle of the heart in a manner empty, hardly a ſpoonful of blood therein. Phil. Tranſ. No 240. Or both the experiments may be together met with in Lowth. Abridg. vol. 3. p 66. 67.

This opinion of our learned Thurſton the late learned Ettmullerus eſpouſed, who being particular in reckoning up the uſes of reſpiration, I ſhall therefore the more largely cite him. Reſpiration, ſaith he, ſerves, '1. Ad olfactum. 2. Ad ſcreatum et ſputationem. 3. Ad oſcitationem, tuſſim, ſternutationem, emunctionemque. 4. Ad liquidorum ſorbitionem, ſuctionemve. 5. Ad loquelam, cantum, clamorem, riſum, flatum, &c. 6. Ad foecum alvi, urinæ, foetus molæve, nec non ſecundinarum expulſionem. 7. Ad promovenda ventriculi, inteſtinorum, lacteorumque vaſorum, &c. contenta. 8. Ad halitus aqueos ſanguinis e pulmonibus, aeris ope, exportandos. 9. Ad diapnoen. 10. Ad exactiorem chyli, lymphæque, necnon ſanguinis——miſcelam.

'11. Ad conciliandum ſanguini——coccineam rubedinem, &c. '12. Nec moroſe negabimus aerem——pulmones et ſanguinem 'illos tranſcurrentem, minus calida reddere, &c. 13. Quod de'nique aer ſanguini ſingulis reſpirationibus aliquantilla ſui parte 'admixtus. pauciſſimas quaſdam in ſpirituum animalium elabo'ratione particulas ſimul contribuat.' All theſe uſes, although of great conſequence, yet he thinks rather conduce to the well being, than the being of the animal; becauſe without any of them, the animals would not ſo ſpeedily die, as it doth by ſtrangling, or in the air-pump. He therefore aſſigns a 14th, and the principal uſe of reſpiration to be, 'For the paſſing of the 'blood through the lungs, that is thrown into them by the heart.' Etmul. Diſſert. 1. cap. 10 ſect 1. 2. et 16.

But the late Dr. Drake with great ingenuity and addreſs (like a perſon ſo conſiderable for his years, as he was in his time) not only eſtabliſhed this notion of reſpiration, but alſo carries it farther, making it the true cauſe of the diaſtole of the heart which neither Borelli, Lower, or Cowper, much leſs any before thoſe great men, have well accounted for. That the heart is a muſcle is made evident beyond all doubt by Dr. Lower. And that the motion of all muſcles conſiſts in conſtriction, is not to be doubted alſo. By which means the ſyſtole is eaſily accounted for. But foraſmuch as the heart hath no antagoniſt-muſcle, the diaſtole hath puzzled the greateſt wits. But Dr. Drake, with great judgment and much probability of reaſon, maketh the weight of the incumbent atmoſphere to be the true antagoniſt to all the muſcles, which ſerve both for ordinary inſpiration; and the conſtriction of the heart. The particulars of his opinion may be ſeen in his anatomy, l. 2. c. 7. And in Phil. Tranſ. N° 281.

And I remember when I was at the univerſity my moſt ingenious and learned tutor Dr. Willis, when he read anatomy to us, was of opinion, that the lungs were blown up by the weight of the incumbent air, and repreſented the manner of reſpiration in this manner, viz, he put a bladder, into a pair of bellows, turning ſary concomitants of one another. Moſes [c] expreſſeth animal life by the breath of life.' Saith he, ' Gen. vii. 21, 22. All fleſh that moveth on the ' earth, fowl, cattle, beaſt, creeping things, and ' man; all in whoſe noſtrils was the breath ' of life, in the dry land died. So the pſalmiſt ' Pſal. civ. 29. ' Thou takeſt away their breath they die.' So grand an act therefore in common to all animals, may juſtly deſerve a place in this ſurvey of the works of God in the animal kingdom.

---

back the neck of the bladder, and tying it faſt, ſo that no air might enter in between the bladder and bellows. This being done when the bellows were opened, the bladder would be blown up by the weight of the incumbent air; and when ſhut, the air would be thereby preſſed forcibly out of the bladder, ſo as to blow the fire. This experiment I take notice of here, becauſe (beſides the illuſtration it gives to reſpiration) that great genius ſeems to have had a truer notion of this phænomenon, then was very common then, viz about the year 1677, or 78: as alſo, becauſe I have, in ſome authors, met with the ſame experiment, without mention of Dr. Willis, whoſe I take it to have been.

Another uſe of great conſideration, the already-commended Dr. Cheyne aſſigns; namely, to form the elaſtic globules of which the blood principally conſiſts, without which there would be a general obſtruction in all the capillary arteries. Cheyne's Philoſ. Princ. of Nat. Relig. or Harris's Lex. Tech. in Lungs.

[c] Gen. ii. 7.——vi. 17. and vii. 15.

And here I might launch out into am ample deſcription of all the parts miniſtering to this neceſſary act, and ſhew the curious contrivance, and artificial ſtructure of them; but a tranſient view ſhall ſuffice. I might begin with the outward guards, the noſe and mouth; but theſe have been already touched upon. But the exquiſite mechaniſm of the larinx, its variety of muſcles, its cartilages, all ſo exquiſitely made for the purpoſe of reſpiration, and forming the voice [d], are very admirable: and no leſs ſo is the tongue [c] which miniſters to that, and many other uſes too.

---

[d] Becauſe it would be endleſs to ſpecify the curious mechaniſm of all the parts, concurring to the formation of the voice; I ſhall therefore for a ſample note only two things: 1. There are thirteen muſcles provided for the motion of the five cartilages of the larynx. Gibſ. Anat. l. 2. c. 14. a ſign of the careful and elaborate proviſion that is made for the voice. 2. It is a prodigious faculty of the glottis, in contracting and dilating itſelf with ſuch exquiſiteneſs, as to form all notes. 'For '(as the late ingenious Dr. Keil ſaith,) ſuppoſing the greateſt 'diſtance of the two ſides of the glottis, to be one tenth part 'of an inch in ſounding twelve notes, to which the voice eaſily 'reaches; this line muſt be divided into twelve parts, each of 'which gives the aperture requiſite for ſuch a note, with a cer'tain ſtrength. But if we conſider the ſub-diviſion of notes, 'into which the voice can run, the motion of the ſides of the 'glottis is ſtill vaſtly nicer. For if two chords ſounding exact'ly uniſons, one be ſhortened one two thouſandth part of its 'length, a juſt ear will perceive the diſagreement, and a good 'voice will ſound the difference; which is one hundred and nine'ty ſixth part of a note. But ſuppoſe the voice can divide a 'note into a hundred parts, it follows, that the different aper'tures of the glottis actually divide the tenth part of an inch 'into twelve hundred parts, the effect of each of which produ'ces a ſenſible alteration upon a good ear. But becauſe each ſide of

Next, the fabric of the [d] trachea deſerves eſpecial remark. Its valve, the epiglottis on the top, to fence againſt all annoyances; its cartilaginous rings

---

'of the glottis moves juſt equally, therefore the diviſions are 'juſt doubled; or the ſides of the glottis, by their motion, do 'actually divide one tenth part of an inch into two thouſand 'four hundred parts. Keil's Anat. cap. 3. ſect. 7.

[c] Among the inſtruments of ſpeech, the tongue is a neceſſary one; and ſo neceſſary, that it is generally thought no ſpeech can be without it. But in the third tome of the Ephem. Germ. is publiſhed, 'Jac. Rolandi Agloſſoſtomographia, ſive De'ſcriptio Oris ſine Lingua quod perfecte loquitur et reliquas ſuas 'functiones naturaliter exercet.' The perſon deſcribed is one Pet. Durand, a French boy of eight or nine years old, who, at five or ſix, loſt his tongue by a gangrene, occaſioned by the ſmall pox: notwithſtanding which, he could, as the title ſaith, ſpeak perfectly, as alſo taſte, ſpit, ſwallow, and chew his food; but this latter he could do only on that ſide he put it into, not being able to turn it to the other ſide of his mouth.

In the ſame tract, chap. 6. is this obſervation of Ventriloquous perſons. 'Memini me a quodam ſat celebri anatomico 'audiviſſe, dum de duplicatura mediaſtini ageret, ſi membrana 'iſta duplex naturaliter unita in duas partes divdatur, loquelam 'quaſi ex pectore procedere, ut circumſtantes credant Dæmoni'acum hunc, aut Sternomythum.

[d] 'The variation of the wind-pipe is obſervable in every 'creature, according as it is neceſſary for that of the voice. In

'an

rings[e] nearly invironing it, with its membraneous part next the gullet, to give the freer paſſage to the deſcent of the food: and laſtly, its inner tegument, of exquiſite ſenſe to be readily affected with, and to make efforts againſt every thing that is hurtful or offenſive; theſe, I ſay, do all juſtly deſerve our admiration.

And

'an urchin, which hath a very ſmall voice, it is hardly more than membranous: and in a pigeon, which hath a low and ſoft note, it is partly cartilaginous, and partly membraneous. In an owl, which hath a good audible note, it is more cartilaginous; but that of a jay hath hard bones inſtead of cartilages; and ſo of a linnet: whereby they have both of them a louder and ſtronger note,' &c.

'The rings of the wind-pipe are fitted for the modulation of the voice; for in dogs and cats, which in the expreſſion of divers paſſions uſe a great many notes, as men do, they are open and flexible, as in man. Whereby all, or any of them, are dilated or contracted, more or leſs, as is convenient for a higher or deeper note, &c. whereas in ſome other animals, as in the Japan-peacock, which uſeth hardly more than one ſingle note, they are entire,' &c. Grew's Coſmol. Sacr. book i. chap. 5. ſect. 9, 10.

[e] It its a further manifeſt indication of ſingulr deſign in the cartilaginous rings of the aſpera arteria, that all the way where they are contiguous to the oeſophagus, they are membranous, to afford an eaſy paſſage to the food; but after that, in the bronchi, they are ſome completely angular, ſome triangular, &c. And another obſervable is, the lower parts of the ſuperior cartilages

lages

And no leſs prodigious are the parts farther within; the bronchi, the veſiculæ [f] with their

---

lages, receive the upper parts of the inferior in the bronchi; whereas in the aſpera arteria, the cartilages run and remain parallel to one another, which is a noble difference of mechaniſm in this, in a manner, one and the ſame part enabling the lungs, and bronchi, to contract themſelves in expiration, and to extend and dilate themſelves in inſpiration.

[f] I ſhall not here intrench ſo much upon the anatomiſt's province, to give a deſcription of the lungs, although it be a curious piece of God's workmanſhip; but refer to ſignior Malpighi, the firſt diſcoverer of their veſiculæ in 1660, in his two letters to Borelli de Pulmon. Alſo to Dr. Will's Pharm. rat. p 2. ſect. 1. c. 1. de Reſp. Orig. et Vſ. who as he wrote after Malpighi, ſo hath more accurately deſcribed thoſe parts; and to Mr Cowper's Anat. tab. 24, 25. And if the reader hath a mind to ſee what oppoſition ſignior Malpighi's diſcoveries met with at home and abroad, and what controverſies he had on that account; as alſo his cenſures of Dr. Willis's deſcription and figures, he may conſult Malpighi's life, written by himſelf, p. 4 to 21.

That the lungs conſiſt of veſiculæ, or lobuli of veſiculæ admitting of air from the bronchi, is viſible, becauſe they may be blown up, cleanſed of blood, and ſo dried. But Mr. Cowper ſaith, he could never part the lobuli, (ſo as to make Dr. Willis's fig. 1. tab. 3. and 4.) ſo that probably the veſiculæ are contiguous to one another throughout each lobe of the lungs. And not only air, but Diemerbroec proves, that the veſiculæ admit of duſt alſo, from two aſthmatic perſons he opened; one a ſtonecutter's man, the veſiculæ of whoſe lungs were ſo ſtuffed with duſt, that in cutting, his knife went as if through a heap of ſand: the other was a feather driver, who had theſe bladders filled with the fine duſt or down of feathers.

muſcular fibres [g] as ſome aſſert they have, together with the arteries and veins, which every where accompany the airy paſſages, for the blood to receive there, its impregnations from the air.

From hence I might proceed to the commodious form of the ribs [h], the curious mechaniſm

---

[g] There is a conſiderable difference between Dr. Willis, and Etmuller, viz. whether the veſiculæ of the lungs have any muſcular fibres, or not? Etmuller expreſly ſaith, 'Nullas fibras muſculoſas, multo minus rubicundam muſculorum compagem (ſunt enim veſiculæ albidæ et fere diaphanæ) in ipſis reperiri.' 'Ubi ſup. c. 6. ſect. 2. And afterwards, ſect. 3. 'Pulmones eſſe molles flexileſque muſculoſis fibris ceu propriæ explicationis organis deſtitutos.' But Dr. Willis, as expreſly aſſerts, they have muſculous fibres, and aſſigns an excellent uſe of them; 'Celelulæ iſtæ veſiculares, ut nixus pro expiratione contractivos edant, etiam fibras, uti per microſcopium plane conſpicere eſt, muſculares obtinent.' Ubi ſup. ſect. 16. And in the next ſection, 'Ut pro data occaſione majorem aeris copiam exſufflent, aut materiam excutiendam ejiciant, fibris muſcularibus donatæ, ſeſe arctius contrahunt, contentaque ſua penitus exterminant. Et enim ordinariæ pectoris ſyſtolæ quas muſculorum relaxationes ex parte efficiunt, aerem forſan totum a trachea et bronchis, haud tamen a veſiculis quaque vice ejiciunt; propter has, quoties opus erit inaniendas, et totius pectoris cavitas plurimum anguſtatur, et cellulæ ipſæ veſiculares a propriis fibris conſtrictis coarctantur.'

[h] 'Circa hos motus [ſcil pectoris dilatationem, &c.] divini conditoris mechaniceo, ad regulas mathematicas plane adaptatam,

of the intercoſtal muſcles [i], the diaphragm, and all the other muſcles [k], miniſtering both to the ordinary, and extraordinary offices of reſpiration

---

‘ aptatum, ſatis admirari non poſſumus: ſiquidem nulla alia in ‘ re manifeſtius, ‘Ο Θεὸς γεωμετρεῖν videtur. Quippe cum pectoris, tum ampliatio, tum coarctatio a quibuſdam muſculis ‘ (quorum munus unicum eſt contrahere) perfici debeat; res ita ‘ inſtituitur, ut coſtæ quæ thoracis, velut parallelogrammatis oblongi verſus cylindrum incurvati, latera efformant in figuram ‘ modo quadratam, cum angulis rectis, pro pectoris ampliatione; ‘ modo in rhomboidem, cum angulis acutis pro ejuſdem contractione, ducantur,’ &c. Willis, ubi ſupra, ſect. 28.

Galen having ſpoken of the parts miniſtering to reſpiration, concludeth, ‘. Nihil uſquam a natura illo pacto per incuriam, ‘ fuiſſe præteritum, quæ cum omnia præſentiret et provideret, ‘ quæ ſunt neceſſaria illa, quæ cauſa alicujus extiterunt conſecutura omnibus inſtaurationes parare occupavit, cujus apparatus copioſa facultas admirabilem ſapientiam teſtatur.’ De Uſu Part. l. 5. c. 15. See alſo l. 6. c. 1.

[i] For the ſtructure of the intercoſtals, midriff, &c. I ſhall refer to Dr. Willis, and other anatomiſts. But Dr. Drake taxeth Dr. Willis with an error, in fancying there is an oppoſition in the office of the intercoſtals, by reaſon that the fibres of the external and internal intercoſtal's decuſſate; that therefore the external ſerve to raiſe the ribs, the internal to draw them down. But Dr. Drake is of Steno's, and Dr. Mayow's opinion, that notwithſtanding the decuſſation of their fibres, the power they exert upon, and the motion they effect in the ribs, is one and the ſame. Drake's Anat. l. 2, c. 7, and l. 4. c. 5. Mayow de Reſpir. c. 7.

[k] Although Dr. Drake, and ſome others, deny the intercoſtals being antagoniſt muſcles, as in the preceding note; yet they

But paſſing them by, I ſhall ſtop at one prodigious work of nature, and manifeſt contrivance of the Almighty Creator, which, although taken

and moſt other anatomiſts that I have met with, attribute a conſiderable power to them in the act of reſpiration, as they do alſo to the ſubclavian and triangular muſcles; but the learned Etmuller denies it for theſe three reaſons, 1. ‘Quia reſpirando nullam in illis contractionem ſentio. 2. Quia——ſibi invicem non adducuntur, &c. 3. Quia coſtæ omnes ab aliis modo enarratis muſculis moventur, idque ſimul, &c. Intercoſtales itaque, necnon ſubclavios muſculos coſtis, parietum inſtar, complenda interſtitia intercoſtalia, pectuſque integrandum, ac coſtas connectendas, interjectos eſſe, probabiliter concludo; quo munere triangulares etiam.—fungi, rationi conſentaneum eſt. Etmul. Diſſert. 2. c. 4 ſect. 6.

But as to the uſe of the triangular muſcle in reſpiration, we may judge of it, from its remarkable ſize and uſe in a dog: of which Dr. Willis gives this account from Fallopius: ‘In homine parvus adeo et ſubtilis iſte [muſculus] eſt, ut vix pro muſculo accipi queat: in cane per totum os pectoris protenditur. et cartilagines omnes, etiam verarum coſtarum ſterno inoſculetas, occupat: cujus diſcriminis ratio divinam circa animalium fabricas providentiam plane indicat. Quippe cum hoc animal, ad curſus velociſſimos et diu continuandos natum, quo ſanguis, dum intenſius agitatur, rite accendatur eventileturque aerem celerrime et fortiter uti ſuperare, ita etiam expirare debet——idcirco propter hunc actum firmius obeundum (cujus in homine haud magnus eſt uſus) muſculus caninus molem ingentem et tanto operi parem ſortitur.’ Willis, ubi ſupra, ſect. 32.

Ray's

taken notice of by others [l] yet cannot be eaſily paſſed by in the ſubject I am upon; and that is, the circulation of the blood in the fœtus in the womb, ſo different from the method thereof after it is born. In the womb, whilſt it is one body with the mother, and there is no occaſion nor place for reſpiration, there are two paſſages [m] on purpoſe for the tranſmiſſion of the blood without paſſing it through the lungs. But as ſoon as the fœtus is born, and becomes thereby a perfectly diſtinct being, and breathes for itſelf, then theſe two paſſages are ſhut up; one nearly obliterated, the other becomes only a ligament, except in ſome creatures that are amphibious or are forced to lie long under water, in whom theſe paſſages probably remain open[n].

---

[l] Ray's Wiſdom of God in the Creation, page 343.

[m] Mr. Cheſelden, an ingenious and moſt accurate anatomiſt, having ſomewhat particular in his obſervations about the circulation of the blood through the heart of the fœtus, I ſhall preſent the reader with ſome of his obſervations, which he favoured me with the ſight of. 'The blood, ſaith he, which is
'brought to the heart by the aſcending cava, paſſes out of the
'right auricle into the left, through a paſſage called foramen
'ovale in the ſeptum [common to them both] without paſſing
'through the right ventricle, as after the birth, while the blood
'from the deſcending cava paſſeth through the right auricle and
'ventricle into the pulmonary artery, and thence into the aorta
'through the duct, betwixt that and the pulmonary artery, called
'ductus arterioſus, whilſt a ſmall portion of the blood, thrown
'into the pulmonary artery, paſſeth through the lungs, no more
'than is ſufficient to keep open the pulmonary veſſels. Thus
'both ventricles are employed in driving the blood through
'the aorta to all parts of the foetus, and to the mother too.
'But after the birth, the blood being to be driven from the
'aorta through the foetus alone, and not the mother too, one
'ventricle becomes ſufficient whilſt the other is employed in
'driving the blood through the lungs, the ductus adterioſus being

And

'ing ſhut up by means of the alteration of its poſition, which 'happens to it from the raiſing of the aorta by the lungs when 'they become inflated. After that the blood is thus driven 'into the lungs, in its return it ſhuts the valve of the foramen 'ovale againſt the foramen itſelf, to whoſe ſides it ſoon ad'heres, and ſo ſtops up the paſſage. The ductus arterioſus; 'or ductus arterioſus in ligamentum verſus, is ſeldom to be 'diſcerned but in adult bodies, but the figure of the foramen o'vale is never obliterated.'

[n] It hath been generally thought to be not improbable, but that on ſome occaſions the foramen ovale may remain open in man. In a girl of four or five years of age, Dr. Conner found it but half cloſed, and in the form of a creſcent. And he thinks ſomewhat in this kind might be in the perſon whoſe ſkeleton was found to have no joints in the back-bone, ribs, &c. Of which a deſcription, with cuts, may be found in Phil. Tranſ. N° 215. And more largely in his Diſſ. Med. Phyſ. de ſtupendo Oſſium coalitu, where he adds to the girl, in whom the foramen ovale was not ſhut, a like obſervation of another girl he opened at Oxford of three years old; 'In qua foramen ovale 'fere erat occluſum, in medio tamen, exili foramine per quod 'turundam facile tranſmiſi, erat pervium,' p. 30. So Mr. Cowper (than whom none more accurate and better judge) ſaith, 'I 'have

And now what action of any rational creature, what is there in a man's life, that doth more plainly

---

‘ have often found the foramen ovale open in the adult.’ Anat. Appen. fig. 3. But Mr. Cheſelden is of a different opinion, of which in the following note.

From ſomewhat of this cauſe, I am apt to think it was that the Tronningholm gardiner eſcaped drowning, and ſome other mentioned by Pechlin. His ſtories are, Hortulanus Tronningholmenſis etamnum vivens, annós natus 65, pro illa ætate ſatis adhuc valens, et vegetus cum ante 18 annos, alii in aquas delapſo opem ferre vellet, forte fortuna et ipſe per glaciem incautius procedens, aquas incidit 18 ulnas profundas: ubi ille corpore erecto quaſi ad prependiculum, pedibus funde adhæſit. Conſtitit ſic per 16 horas, antequam produceretur in auras. Dixit autem ſimul ac infra aquarum ſuperficiem fuit demerſus, ſtatim obriguiſſe totum et, ſi quem tum habuit motum et ſenſum amiſiſſe, niſi quod ſonantes Stockholmii campanas etiam ſub aquis obſcurius percipere ſibij ſit viſus. Senſit etiam ſtatim ſeſe velut veſiculam ori applicaſſe, adeo ut aqua nulla os penetraverit, in aures vero tranſitum, etiam ſentiente illo, habuerit; atque inde auditum ſuum debilitatum aliquandiu eſſe. Hoc ſtatu dum 16 horas permanſit fruſtra quæſitus tandem, repertum, conto in caput infixo, cujus etiam ſenſum ſe habuiſſe dixit, fundo extraxerunt, ſperantes ex more aut perſuaſione gentis revicturum eſſe. Itaque pannis linteiſque productum obvölvunt, ne aer admitti poſſit perniciosſus futurus ſubito illapſu: cuſtoditum ſic ſatis ab aere ſenſim ſenſimque tepidiori loco admovent, mox calidis adoriuntur, faſciis, fricant radunt et ſufflaminatum tot horis ſanguinis corporiſque motum negotioſa illa opera reducunt: denique antaplecticis et genialibus liquoribus vitæ reddunt et priſtinæ mobilitati. Retulit is atque oſtendit ſe etiamnum in capite circumferre veſtigia violentiæ a conto illatæ et cephalalegiis vexari graviſſimis. Et propter hunc ipſum caſum

‘ religioſe

plainly ſhew deſign, reaſon and contrivance, than this very act of nature doth the contrivance and deſign

---

'religioſe a popularibus, et hujuſce rei teſtibus probatum, ſereniſſimæ reginæ matris munificentia et annuo ſtipendio eſt donatus——et ſereniſ. Principi——oblatus vivus ſui teſtis——Conſignatam manu habes hiſtoriam D. Tilaſii, Biblioth. Reg· Præfecti, qui teſtatus eſt ſe prænoviſſe mulierem, qu tres ipſos dies ſub aquis hæſit, et ſimilem in modum, quo Hortulanus ille, reſuſcitata, adhuc dum lucis plena fruitur uſura. Accedit Nob. Burmanni——fides, qui confeſſus eſt,——ſe in pago Boneſs parochiæ Pithoviæ concionem frequentaſſe funebrem, in qua, dum acta recenſeret præco ſenis cujudam ſeptuagenarii Lau. Jonæ ————adiverit ex ore concionatoris, vivum eum, adoſcentem 17 annorum, aquis ſubmerſum, 7 demum hebdomada (rem prodigioſam !) extractum ad ſe rediiſſe vivum et incolumem.' Pechlin. de. Aer. et Alim. def. c. 10.

Shall we to this cauſe or to the oſſification, or more than ordinary ſtrength of the wind pipe, attribute the recovery to life of perſons hanged? Of which Pechlin gives an inſtance that fell under his own knowledge, of a woman hanged, and in all appearance dead, but recovered by a phyſician accidentally coming in, with a plentiful adminiſtration of Spir. Sal. Armon. Pechl. ibid. c. 7. And the ſtory of Anne Green, executed at Oxford Dec.14, 1650. is ſtill well remembered among the ſeniors there. 'She was hanged by the neck near half an hour, ſome of her friends in the mean time thumping her on the breaſt, others hanging with all their weight upon her legs, ſometimes lifting her up, and then pulling her down again with a ſudden jirk, thereby the ſooner to diſpatch her out of her pain;' as her printed account wordeth it. After ſhe was in her coffin, being obſerved to breathe, a luſtly fellow ſtamped with all his force, on her breaſt and ſtomach, to put her out of her pain. But by the aſſiſtance of Dr. Peity, D. Willis, Dr. Bathurſt, and Dr.

deſign of the great God of nature? What is thought and contrivance, if this be not! namely that there ſhould be a temporary part in the body made juſt for the preſent exigence; to continue whilſt there is occaſion for it, and to ceaſe when there is none; in ſome creatures to remain always, by reaſon of their amphibious way of living, and in land-animals, purely ſuch, to ceaſe.

Another excellent contrivance a-kin to the laſt, is, for the preſervation of ſuch creatures whoſe occaſions frequently neceſſitate them to live without, or with but little reſpiration: fiſhes might be named here, whoſe habitation is always in the waters; but theſe belong to an element which I cannot at preſent engage in. But there are many animals of our own element, or partly ſo, whoſe organs of reſpiration, whoſe blood, whoſe heart and other inſtruments of life, are admirably accommodated to their method of living: thus many

---

Dr. Clarke, ſhe was again brought to life. I myſelf ſaw her many years after, after that ſhe had, I heard born divers children. The particulars of her crime, execution, and reſtauration, ſee in a little pamphlet, called, News from the Dead, written, as I have been informed, by Dr. Bathurſt, (afterwards the moſt vigilant and learned preſident of Trinity-College, Oxon,) and publiſhed in 1651. with verſes upon the occaſion.

many amphibious creatures [o] who live in water as well as air; many quadrupeds, birds, inſects, and other animals, who can live ſome hours, days, yea, whole winters, with little or no reſpiration, in a torpitude, or ſort of ſleep, or middle ſtate between life and death: the proviſion made for theſe peculiar occaſions of life, in the fabric of the lungs, the heart, and other parts of ſuch creatures [p], is manifeſtly the work of him who, as St. Paul ſaith [q], 'Giveth to all 'breath and life, and all things,'

---

[o] The ſea-calf hath the foramen ovale, by which means it is enabled to ſtay long under the water, as the Paris Anatomiſts. Of which ſee in book vi. chap. 5.

But the fore-commended Mr. Cheſelden, thinks the foramen ovale is neither open in amphibious ceratures, nor any adult land-animals. 'When I firſt, ſaith he, applied myſelf to the 'diſſection of human bodies, I had no diſtruſt of the frequent 'accounts of the foramen ovale being open in adults; but I find 'ſince, that I miſtook the oſtium venarum coronariarum for the 'foramen. The like I ſuppoſe authors have done, who aſſert that 'it is always open in amphibious animals; for we have made diligent enquiry into thoſe animals, and never found it open. 'Neither would that, as they imagine, ſerve theſe creatures to 'live under water, as the foetus doth in utero, unleſs the ductus 'arterioſus was open alſo.'

This opinion of Mr. Cheſelden hath this to render it probable, that the oſtium venarum coronariarum is ſo near the foramen ovale that without due regard, it may be eaſily miſtaken for it. Such therefore as have opportunity of examining this part in amphibious animals, or any other ſubjects, ought to ſeek for the oſtium, whenever they ſuſpect they have met with the foramen.

---

[p] Of the ſingular conformation of the heart and lungs of the tortoiſe, which is an amphibious animal, ſee book vi. chap. 5.

[q] Acts xvii. 15

CHAP.

CHAP. VIII.

OF THE MOTION OF AMIMALS.

NEXT to the two grand acts of animal life their ſenſe and reſpiration, I ſhall conſider their motion, or locomotive faculty, whereby they convey themſelves from place to place, according to their occaſions and way of life: and the admirable apparatus to this purpoſe is a plain demonſtration of God's particular foreſight care and ſpecial providence towards all the animal world.

And here I might view, In the firſt place, the muſcles, their curious ſtructure [r], the nice tacking

---

[r] That the muſcles are compounded of fibres, is viſible enough. Which fibres, the curious and ingenious Borelli ſaith, are

ing them to every joint, to pull it this way and that way, the other way, according to the ſpecial purpoſe, deſign, and office of every ſuch joint: alſo their various ſize and ſtrength; ſome large and corpulent, others leſs, and ſome ſcarce viſible to the naked eye; all exactly fitted to every place, and every uſe of the body. And laſtly, I might take notice of the muſcular motion, both involuntary and ſpontaneous [a].

Next

---

are cylindraceous; not hollow, but filled with a ſpungy, pithy ſubſtance, after the manner of Elder, as he diſcovered by his microſcopes. Borel. de Mot. Animal. Part. 1.

Theſe fibres, he ſaith, are naturally white; but derive their redneſs only from the blood in them.

Theſe fibres do in every muſcle (in the belly at leaſt of the muſcle) run parallel to one another, in a neat orderly form. But they do not all tend they ſame way, but ſome run aſlant, ſome long ways, &c. according to the action or poſition of each reſpective muſcle. The particulars of which, and of diverse other obſervable in the muſcles, would beſides figures, take up too much room in theſe notes: and therefore I muſt refer to the anatomiſts, particularly Steno, Borelli, Cowper, &c.

[a] The infinite Creator hath generally exerted his art and care, in the proviſion made by proper muſcles and nerves, for all the different motions in animal bodies, both involuntay, and voluntary. It is a noble providence, that moſt of the vital motions, ſuch as the heart, ſtomach, guts, &c. are involuntary, the muſcles acting whether we ſleep or wake, whether we will or no.

And

Next I might ſurvey the ſpecial fabric of the bones [t], miniſtering to animal motion. Next, I might

---

And it is no leſs providential that ſome, even of the vital motions, are partly voluntary, partly involuntary, as that for inſtance, of breathing, which is performed both ſleeping and waking; but can be intermitted for a ſhort time on occaſion, as for accurate hearing any thing, &c. or can be increaſed by a ſtronger blaſt, to make the greater diſcharges of the blood from the lungs, when that any thing overcharges them. And as for the other motions of the body, as of the limbs, and ſuch as are voluntary, it is no leſs providential, that they are abſolutely under the power of the will; ſo as that the animal hath it in his power to command the muſcles and ſpirits, or any part of its body, to perform ſuch motions and actions as it hath occaſion for.

[t] 'Quid dicam de oſſibus? quæ ſubjecta corpori mirabiles 'commiſſuras habent, et. ad ſtabilitatem aptas, et ad. artus fini'endos accommodatas, et ad motum, et ad omnem corporis 'actionem,' Cicer. de Nat. Deor. l. 2. c. 55.

By reaſon it would be endleſs to mention all the curioſities obſervable in the bones, I ſhall, for a ſample, ſingle out only an inſtance or two, to manifeſt, that deſign was uſed in the ſtructure of theſe parts in man.

The firſt ſhall be in the back-bone, which, among many others, hath theſe two things remarkable. 1. Its different articulations from the other joints of the body. For here moſt of the joints are flat, and withal guarded with aſperities and hollows, made for catching and holding; ſo as firmly to lock and keep the joints from laxations, but withal to afford them ſuch a motion, as is neceſſary for the incurvations of the body. 2.

The difference of its own joints in the neck, back and loins. In the neck, the atlas, or upper vertebra, as alſo the dentata are curiouſly made, and jointed, differently from the reſt, for the commodious and eaſy bending and turning the head every way. In the thorax, or back, the joints are more cloſe and firm; and in the loins, more lax and pliant; as alſo the ſpines are different, and the knobs and ſockets turned the quite contrary way, to anſwer the occaſions the body hath to bend more there than higher in the back. I ſhall cloſe this remark with the late ingenious Dr. Kell's obſervation.

'The ſtructure of the ſpine is the very beſt that can be con-'trived; for had it been all bone, we could have had no mo-'tion in our backs; had it been of two or three bones articu-'lated for motion, the medulla ſpinalis muſt have been neceſ-'ſarily bruiſed at every angle or joint; beſides, the whole 'would not have been ſo pliable for the ſeveral poſtures we 'have occaſion to put ourſelves in. If it had been made of ſe-'veral bones without intervening cartilages, we ſhould have had 'no more uſe of it than if it had but one bone. If each verte-'bra had had its own diſtinct cartilages, it might have been ea-'ſily diſlocated. And laſtly, the oblique proceſſes of each ſupe-'rior and inferior vertebra keep the middle one, that it can nei-'ther, be thruſt backwards nor forwards to compreſs the medulla 'ſpinalis.' Keil's Anat. cap. 5. ſect. 8.

Compare here what Galen ſaith of the articulations, ligaments, perforation, &c. of the ſpine, to prove the wiſdom and providence of the maker of animal bodies, againſt ſuch as found fault with nature's works among which he names Diagoras, Anaxagoras, Aſclepiades, and Epicurus. Vide Galen de Uſu part. l. 12 init. and cap. 11, &c. alſo l. 13. init,

2. The next inſtance ſhall be in one or two things, wherein the ſkeletons of the ſexes differ. Thus the pelvis made in the belly by the ilium, oſſa coxendicis, and pubis, is larger in a female

might take notice of the joints [u], their complete

form

---

than male ſkeleton, that there may be more room for lying of the viſcera and foetus. So the cartilage bracing together the two oſſa pubis, or ſharebones, Bartholine ſaith, is twice thicker and laxer in women than men: as alſo is the cartilage that tieth the os ſacrum to its vertebra; and all to give way to the paſſage, of the foetus.

Another conſiderable difference is in the cartilaginous production of the ſeven long ribs, whereby they are braced to the breaſt-bone. Theſe are harder and firmer in women than in men; the better to ſupport the weight of the breaſts, the ſucking infant, &c.

[u] It is remarkable in the joints, and a manifeſt act of caution and deſign: 1. That although the motion of the limbs be circular, yet the center of that motion is not a point, but an ample ſuperficies. In a point, the bones would wear and penetrate one another; the joints would be exceedingly weak, &c. but the joints conſiſting of two large ſuperficies, concave, and convex ſome furrowed and ridged, ſome like a ball and ſocket, and all lubricated with an oily ſubſtance, they are incomparably prepared both for motion and ſtrength. 2. That the bones next the joint are not ſpungy, as their extremities commonly are, nor hard and brittle, but capped with a ſtrong, tough, ſmooth, cartilaginous ſubſtance, ſerving both to ſtrength and motion.

But let us here take notice of what Galen mentions on this ſubject,' ‘ Articulorum unuſquiſque eminentiam cavitati immiſ‑
‘ ſam habet: veruntamen hoc fortaſſe non adeo mirabile eſt: ſed
‘ ſi conſiderata omnium totius corporis oſſium mutua connexi‑
‘ one, eminentias cavitatibus ſuſcipientibus æquales ſemper inve‑
‘ neris, hoc mirabile. Si enim juſto amplior eſſet cavitas, laxus ſane

form adjuſted to the place, and office they are employed in; their bandage keeping them from luxations; the oily matter [x] to lubricate them, and their own ſmoothneſs to facilitate their motion.

And laſtly, I might trace the various nerves throughout the body, ſent about to miniſter to its

---

‘ et infirmus fieret articulus; ſi ſtrictior, motus difficulter fieret, ut qui nullam verſionem haberet; ac periculum eſſet non parvum eminentias oſſium arctatas frangi ſed horum neutrum factum eſt.—Sed quoniam ex tam ſecura conſtructione periculum erat, ne motiones difficilius fierent, et eminentiæ oſſium extererentur, duplex rurſus auxilium in id natura molita eſt. 1. Cartilagine os utrumque ſubjungens, atque obtinens: alterum ipſis cartilaginibus humorem unctuoſum velut oleum, ſuperfundens; per quem facile mobilis et attritu contumax omnis articulatio oſſium facta eſt.—Ut undique diligenter articulus omnis cuſtodiretur, ligamenta quædam ex utroque oſſe produxit natura.’ Galen de Uſ. Part. l. 1. c. 15.

[x] For the affording this oily or mucilaginous matter, there are glandules very commodiouſly placed near the joints, ſo as not to ſuffer too great compreſſion by the motion of the neighbouring bones, and yet to receive a due preſſure, ſo as to cauſe a ſufficient emiſſion of the mucilage into the joints. Alſo, another thing conſiderable is, that the excretory ducts of the mucilaginous glands have ſome length in their paſſage from the glands to their mouths; which is a good contrivance, to prevent their mouths being oppreſſed by the mucilage, as alſo to hinder the too plentiful effuſion thereof, but yet to afford a due expreſſure of it at all times, and on all occaſions, as particluarly in violent and long continued motions of the joints, when there is a greater than ordinary expence of it. See Cowp. An. tab. 79.

various motions [y]. I might conſider their origin [z], their ramifications to the ſeveral parts, and their inoſculations with one another, according to the harmony and accord of one part with another, neceſſary for the benefit of the animal. But ſome of theſe things I have given ſome touches upon already, and more I ſhall mention hereafter [a], and it would be tedious here to inſiſt upon them all.

---

[y] There is no doubt to be made, but that the muſcles receive their motion from the nerves. For if a nerve be cut, or ſtraightly bound, that goes to any muſcle, that muſcle ſhall immediately loſe its motion. Which is doubtleſs the caſe of paralytics; whoſe nerves are ſome of them by obſtructions, or ſuch like means, reduced to the ſame ſtate as if cut or bound.

And this alſo is the cauſe of that numbneſs or ſleepineſs we find oftentimes, by long ſitting or lying on any part.

Neither is this a modern notion only; for Galen ſaith, 'Principium nervorum omnium cerebrum eſt, et ſpinalis medulla.— 'Et nervi a cerebro animalem virtutem accipiunt——Nervorum 'utilitas eſt facultatem ſenſus et motus a principio in partes diducere.' And this he intimates to have been the opinion of Hippocrates and Plato, de Uſ. Part. l. 1. c. 16. et paſſim.

[z] Dr. Willis thinks, that in the brain the ſpirits are elaborated that miniſter to voluntary motion; but in the cerebellum, ſuch as affect involuntary, or natural motions; ſuch as that of the heart, the lungs. &c. Cerebri Anat. c. 15.

[a] See book v. chap. 8.

I ſhall therefore only ſpeak diſtinctly to the locomotive act itſelf, or what directly relates to it.

And here it is admirable to conſider the various methods of nature [a], ſuited to the occaſions of various animals. In ſome their motion is ſwift, in others ſlow; in ſome performed with two, four, or more legs; in ſome with two; or four wings; in ſome with neither[b].

---

[b] To the foregoing, I ſhall briefly add ſome examples of the ſpecial proviſion made for the motion of ſome animals by temporary parts. Frogs and toads, in their tadpole-ſtate, have tails, which fall off when their legs are grown out. The lacerta aquatica, or water-newt, when young, hath four neat ramified fins, two on a ſide, growing out a little above its fore-legs, to poiſe and keep its body upright, (which gives it the reſemblance of a young fiſh) which fall off when the legs are grown. And the nymphæ and aureliæ, of all or moſt of the inſects bred in the waters, as they have particular forms, different from the inſects they produce, ſo have alſo peculiar parts afforded them for their motions in the waters; oars, tails, and every part adapted to the waters, which are utterly varied in the inſects themſelves, in their mature ſtate in the air.

[a] ‘ Jam vero alia animalia gradiendo, alia ſerpendo, ad ‘ paſtum accedunt, alia volando, alia nando.’ Cic. de Natura Deor. l. 2. c. 47.

Compare alſo what Galen excellently obſerves concerning the number of feet in man, and in other animals; and the wiſe proviſion thereby made for the uſe and benefit of the reſpective animals. De Uſu Part. in the beginning of the third book.

And firſt for ſwift or ſlow motions. This we find is proportional to the occaſions of each reſpective animal. Reptiles, whoſe food, habitation, and neſts, lie in the next clod, plant, tree, or hole, or can bear long hunger and hardſhip, they need neither legs nor wings for their tranſportation; but their vermicular or ſinuous motion (performed with no leſs art, and as curiouſly provided for as the legs or wings of other creatures; this, I ſay) is ſufficient for their conveyance.

Man and beaſts, whoſe occaſions require a large room, have accordingly a ſwifter motion; with proper engines for that ſervice; anſwerable to their range for food, their occupation of buſineſs or their want of armature; and to ſecure them againſt harms [c].

---

[c] As I ſhall hereafter ſhew, that the indulgent Creator hath abundantly provided for the ſafety of animals by their cloathing, habitations, ſagacity, and inſtruments of defence; ſo there appears to be a contemperament of their motion with theſe proviſions. They that are well armed and guarded, have commonly a ſlower motion; whereas they that are deſtitute thereof, are ſwifter. So alſo timid helpleſs animals are commonly ſwift; thus deer and hares: but animals endowed with courage, craft, arms, &c. commonly have a ſlower motion.

But for the winged creatures, birds and inſects, as they are to traverſe large tracts of land and water, for their food, for their commodious habitation, or breeding their young, to find places of retreat and ſecurity from miſchiefs; ſo they have accordingly the faculty of flying in the air; and that ſwiftly and ſlowly; a long or ſhort time according to their occaſions and way of life. And accordingly their wings, and whole body, are curiouſly prepared for ſuch a motion; as I intend to ſhew in a proper place [d].

Another remarkable thing in the motive faculty of all creatures, is the neat geometrical performance of it. The moſt accurate mathematician the moſt ſkilful in mechanic motions, cannot preſcribe a nicer motion than what they perform, to the legs and wings of thoſe that walk or fly [e], or to the bodies of thoſe that creep [f]. Neither can the body be more compleatly poiſed for the motion it is to have in every creature, than it already actually is. From the largeſt elephant to the ſmalleſt mite, we find the body artfully balanced[g]. The head not too heavy, nor too light for the reſt of the body, nor the reſt of the body for it[h]. The viſcera are not let looſe, or ſo placed as to ſwag, overbalance or over-ſet the body; but well braced, and diſtributed to maintain the æquipoiſe of the body. The motive parts alſo are admirably well fixed in reſpect to the centre of gravity: placed in the very point, fitteſt to ſupport and convey the body. Every leg beareth his true ſhare of the body's weight. And the wings ſo nicely are ſet to the centre of gravity, as even in that fluid medium, the air, the body is as truly balanced, as we could have balanced it with the niceſt ſcales.

---

[d] See book vii. chap. 1.

[e] See book vii. chap. 1. the end.

[f] See book ix. chap. 1.

---

[g] 'Siquis unquam alius opifex, æqualitatis et proportionis 'magnam habuit providentiam, certe natura habuit in anima-'lium corporibus corformandis; unde Hippocrates eam rectiſſime 'juſtam nominat.' Galen de Uſu Part. l. 2. c. 26.

[h] The make of the bodies of ſome water-fowls, ſeems to contradict what I here ſay, the heads and long necks of ſome as of ſwans, ducks, and geeſe; and the hinder parts of others, as of the doucker and moor hen, and ſome other kinds, ſeeming to be too heavy for the reſt of their body. But inſtead of being an argument againſt, it is a notable inſtance of, the divine art and providence, theſe things being nice accommodations to their way of life. Of ſuch as have long necks, ſee book vii. chap. 2.

And as for ſuch whoſe hinder parts ſeem to over-balance their foremoſt parts, whereby they fly with their bodies in a manner erect, this alſo is an excellent accommodation to their way of life, which is diving rather than flying. Vide book vii. chap. 4.

But among all creatures, none more elegant than the ſizing the body of man, the gauging his body ſo nicely, as to be able to ſtand erect, to ſtoop, to ſit, and indeed to move any way, only with the help of ſo ſmall a ſtay as the feet [i] whoſe mechaniſm of bones, tendons, and muſcles to this purpoſe, is very curious and admirable.

---

[i] See book v. chap. 2.

CHAP. IX.

OF THE PLACE ALLOTTED TO THE SEVERAL TRIBES OF ANIMALS.

HAVING diſpatched the motion of animals, let us in the next place conſider the place which the infinitely wiſe Creator hath appointed them to move and act, and perform the offices of the creation in. And here we find every particular well ordered. All parts of our terraqueous globe fit for an animal to live and act in, are ſufficiently ſtocked with proper inhabitants: the watery element (unfit, one would think, for reſpiration and life) abounding with creatures fitted for it; its bowels abundantly ſtored, and its ſurface well beſpread. The earth alſo is plentifully ſtocked in all its parts, where animals can be of any uſe; not probably the deepeſt bowels thereof indeed, being parts in all likelihood unfit for habitation and action, and where a living creature would be uſeleſs in the world; but the ſurface every where abundantly ſtored.

But that which is moſt conſiderable in this matter, and plainly ſheweth the divine management in the caſe, is that thoſe creatures are manifeſtly deſigned for the place in which they are, and the uſe and ſervices they perform therein. If all the animals of our globe had been made by chance, or placed by chance, or without the divine providence, their organs would have been otherwiſe than they are, and their place and reſidence confuſed and jumbled. Their organs, for inſtance, of reſpiration, of viſion, and of motion, would have fitted any medium, or have needed none; their ſtomachs would have ſerved any food, and their blood, and covering of their bodies been made for any clime, or only one clime. Conſequently all the animal world would have been in a confuſed, inconvenient, and diſorderly commixture. One animal would have wanted food; another habitation, and moſt of them ſafety. They would have all flocked to one, or a few places, taken up their reſt in the temperate zones only, and coveted one food, the eaſieſt to come at, and muſt ſpecious in ſhew;

and ſo would have poiſoned, ſtarved and incommoded one another. But as the matter is now ordered, the globe is equally beſpread, ſo that no place wanteth proper inhabitants, nor any creature is deſtitute of a proper place, and all things neceſſary to its life, health, and pleaſure. As the ſurface of the terraqueous globe is covered with different ſoils, with hills and vales, with ſeas, rivers, lakes, and ponds, with diverſe trees and plants, in the ſeveral places; ſo all theſe have their animal inhabitants, whoſe organs of life and action are manifeſtly adapted to ſuch places and things; whoſe food and phyſic, and every other convenience of life, is to be met with at that very place appointed it. The watery, the amphibious[i], the airy inhabitants, and thoſe on the dry land ſurface, and the ſubterrancous under it, they all live, and act with pleaſure, they are gay, and flouriſh in their proper element and allotted place, they want neither for food, clothing, or retreat; which would dwindle and die, deſtroy, or poiſon one another, if all coveted the ſame element, place, or food.

---

[i] ‘Eſt etiam admiratio nonnulla in beſtiis aquatilibus iis; quæ gignuntur in terra: veluti crocodili, fluviatileſque teſtudines, quædamque ſerpentes ortæ extra aquam, ſimul ac primum niti poſſunt, aquam perſequuntur. Quin etiam anatum ova gallinis ſæpe ſupponimur—[pulli] deinde eas [matres] relinquunt —et effugiunt, cum primum aquam, quaſi naturalem domum videre potuerunt.’ Cic. de Nat. Deor. l. 2. c. 48.

Nay, and as the matter, is admirably well ordered, yet conſidering the world's increaſe, there would not be ſufficient room, food and other neceſſaries for all the living creatures, without another grand act of the divine wiſdom, and providence, which is, the balancing the number of individuals of each ſpecies of creatures, in that place appointed thereto: of which in the next chapter.

CHAP. X.

OF THE BALANCE OF ANIMALS, OR THE DUE PROPORTION IN WHICH THE WORLD IS STOCKED WITH THEM.

THE whole ſurface of our globe can afford room and ſupport only to ſuch a number of all ſorts of creatures; and if by their doubling, trebling, or any other multiplication of their kind, they ſhould increaſe to double or treble that number, they muſt ſtarve, or devour another. The keeping therefore the balance even, is manifeſtly a work of the divine wiſdom and providence. To which end, the great author of life hath determined the life of all creatures to ſuch a length, and their increaſe to ſuch a number, proportional to their uſe in the world. The life of ſome creatures is long, and their increaſe but ſmall, and by that means they do not over-ſtock the world. And the ſame benefit is effected, where the increaſe is great, by the brevity of ſuch creatures lives, by their great uſe, and the frequent occaſions there are of them for food to man, or other animals. It is a very remarkable act of the divine providence, that uſeful creatures are produced in great plenty[l] and others in leſs. The prodigious and frequent increaſe of inſects, both in and out of the waters, may exemplify the one; and it is obſervable in the other, that creatures leſs uſeful, or by their voracity pernicious, have commonly fewer young, or do ſeldomer bring forth: of which many inſtances may be given in the voracious beaſts and birds. But there is one ſo peculiar an animal, as if made for a particular inſtance in our preſent caſe, and that is the cuntur of Peru[m]; a fowl of that magninitude, ſtrength, and appetite, as to ſeize not only the ſheep, and leſſer cattle, but even the larger beaſts, yea, the very children too. Now theſe, as they are the moſt pernicious of birds, ſo are they the moſt rare, being ſeldom ſeen, or only one, or a few in large countries; enough to keep up the ſpecies, but not to overcharge the world.

---

[l] 'Benigna circa hoc natura, innocua et eſculenta animalia foecunda generavit.' Plin. Vut. l. 8. c. 55.

[m] 'Captain J. Strong gave me this account, together with 'a quill-feather of the cuntur [or condor] of Peru. On the 'coaſt of Chili, they met with this bird in about 33° S. Lat. not 'far from Mocha, an iſland in the ſouth ſea— they ſhot it ſitting 'on a cliff, by the ſea-ſide; that it was 16 feet feet from wing to 'wing extended; that the Spaniſh inhabitants told them they were

Thus

‘ were afraid of theſe birds, leſt they ſhould prey upon their children. And the feather he gave me, ſaith the doctor, is two feet ‘ four inches long; the quill part five inches three quarters long ‘ and one inch and a half about in the largeſt part. It weighed ‘ 3 dr. 17 gr. and a half, and is of a dark-brown colour.’ Dr. Sloan in Phil. N°. 208.

To this account, the doctor (in a letter to Mr. Ray, March 31, 1694, with other papers of Mr. Ray's in my hands) adds the teſtimony of Joſ. Acoſtal l. 4. c. 7, and Garcilaſſ. de la Vega, who. l 8. c. 19. ſaith, ‘ There are other fowls, called ‘ cunturs, and by the Spaniards corruptly condors. Many of theſe ‘ fowls having been killed by the Spaniards, had their proportion taken, and, from end to end of their wings meaſured 15 ‘ or 16 feet.—Nature, to temper and allay their fierceneſs, denied them the talons which are given to the eagle; their feet ‘ being tipped with claws like a hen: however, their beak is ‘ ſtrong enough to tear off the hide, and rip up the bowels of an ‘ ox. Two of them will attempt a cow or bull, and devour him: ‘ and it hath often happened, that one of them alone hath aſſaulted boys of ten or twelve years of age and eaten them, ‘ Their colour is black and white, like a magpye. It is well ‘ there are but few of them; for if they were many, they would ‘ very much deſtroy the cattle. They have on the fore part ‘ of their heads, a comb, not pointed like that of a cock; but

‘ rather

Thus the balance of the animal world, is, throughout all ages, kept even; and by a curious harmony, and juſt proportion between the increaſe of all animals and the length of their lives, the world is through all ages well, but not over-ſtored: 'One generation paſ-'ſeth away, and another generation cometh '*;' ſo equally in its room, to balance the ſtock of the terraqueous globe in all ages and places, and among all creatures; that it is an actual demonſtration of our Saviour's aſſertion, Mat. x. 29. that the moſt inconſiderable com-'mon creature, even a ſparrow (two of which 'are ſold for a farthing) doth not fall on the 'ground without our heavenly Father.'

This providence of God is remarkable in every ſpecies of living creatures: but that eſpecial management of the recruits and decays of mankind, ſo equally all the world over, deſerves our eſpecial obſervation. In the beginning of the world, and ſo after Noah's flood, the longevity of men, as it was of abſolute ne-

---

'rather even, in the form of a razor. When they come to 'alight from the air, they make ſuch a humming noiſe, with 'the fluttering of their wings, as is enough to aſtoniſh, or make 'a man deaf.'

* Eccleſ. i. 4.

ceſſity to the more ſpeedy peopling of the new world; ſo is a ſpecial inſtance of the divine Providence in this matter[p]. And the ſame providence appears in the following ages, when the world was very well peopled, in reducing the common age of man then to 120 years (Gen. vi. 3.) in proportion to the occaſions of the world at that time. And laſtly, when the world was fully peopled after the flood (as it was in the age of Moſes and ſo down to our preſent time) the leſſening the common age of man to 70 or 80 years [q], (the age mentioned by Moſes,

---

[p] The divine providence doth not only appear in the longevity of man, immediately after the creation and flood; but alſo in their different longevity at thoſe two times. Immediately after the creation, when the world was to be peopled by one man, and one woman, the age of the greateſt part of thoſe on record was 900 years and upwards. But after the flood, when there were three perſons by whom the world was to be peopled, none of theſe patriarchs, except Shem, arrived to the age of 500; and only the three firſt of Shem's line, viz. Arphaxad, Salah, and Eber, came near that age; which was in the firſt century after the flood. But in the ſecond century, we do not find any reached the age of 240. And in the third century, (about the latter end of which Abraham was born) none, except Terah, arrived to 200 years: by which time the world was ſo well peopled (that part of it at leaſt where Abraham dwelt) that they had built cities, and began to be cantoned into diſtinct nations and ſocieties, under their reſpective kings; ſo that they were able to wage war four kings againſt five, Gen. xiv. Nay, if the accounts of Anian, Beroſus, Manetho, and others, yea, Africanus, be to be credited, the world was ſo well peopled, even before the times we ſpeak of, as to afford ſufficient numbers for the great kingdoms of Aſſyria, Egypt, Perſia, &c. But learned men generally, with great reaſon reject theſe as legendary accounts.

If the reader hath a mind to ſee a computation of the increaſe of mankind, in the three firſt centuries after the flood he may find two different ones of the moſt learned archbiſhop Uſher, and Petavius; together with a refutation of the ſo early beginning of the Aſſyrian monarchy; as alſo reaſons for placing Abraham near 1000 years after the flood, in our moſt learned biſhop Stillingfleet's Orig. Sacr. book iii. chap. 4, ſect. 9.

---

[q] That the common age of man hath been the ſame in all ages ſince the world was peopled, is manifeſt from profane, as well as ſacred hiſtory. To paſs by others: Plato lived to the age of 81, and was accounted an old man. And thoſe which Pliny reckons up, l. 7. c. 48, as rare examples of long life, may, for the moſt part, be matched by our modern hiſtories; eſpecially ſuch as Pliny himſelf gave credit unto. Dr. Plot hath given us diverse inſtances in his hiſtory of Oxfordſhire, c. 2. ſect. 3. and c. 8. ſect. 54, and hiſtory of Staffordſhire, c. 8. ſect. 91, &c. Among others, one is of twelve tenants of Mr. Biddulph's that together made 1000 years of age. But the moſt conſiderable examples of aged perſons among us, is of old Parre of Shropſhire who lived 152 years 9 months, according to the learned Dr. Harvey's account; and Henry Jenkins of Yorſhire who lived 169 years, according to the account of my learned and ingenious friend Dr. Tancred Robinſon; of both which, with others ſee Lowth. Abridg. Phil. Tranſ. v. 3 p. 306. The great age of Parre of Shropſhire, minds me of an obſervation of the reverend Mr. Plaxton, that in his two pariſhes of Kinardſey and Donington in Shropſhire, every ſixth ſoul was ſixty years of age, or upwards. Phil. Tranſ. No. 310.

Pſal. xc. 10. this, I ſay,) is manifeſtly an appointment of the ſame infinite Lord that ruleth the world: for by this means, the peopled world is kept at a convenient ſtay; neither too full nor too empty. For if men (the generality of them, I mean) were to live now to Methuſelah's, age of 969 years, or only to Abraham's, long after the flood, of 175 years, the world would be too much over-run; or if the age of man was limited to that of diverſe other animals, or ten, twenty, or thirty years

---

And if we ſtep farther north into Scotland, we ſhall find diverſe recorded for their great age: Of which I ſhall preſent the reader with only one modern example of one Laurence, who married a wife after he was 100 years of age and would go out to ſea a fiſhing in his little boat, when he was 140 years old: and is lately dead of no other diſtemper but mere old age, ſaith Sir Rob. Sibbald, Prodr. Hiſt. Scot. p. 44 and l. 3. p. 4.

As for foreigners, the examples would be endleſs; and therefore that of Joh. Ottele ſhall ſuffice, who was as famous for his beard, as for being 115 years of age. He was but two Brabant ells and three ninths high, and his long grey beard was one ell and one fourth long. His picture and account may be ſeen in Ephem. Ger. T. 3. obſ. 163.

As for the ſtory Roger Bacon tells, of one that lived 900 years by the help of a certain medicine, and many other ſuch ſtories I look upon them as fabulous. And no better is that of the wandering Jew, named Joh. Buttadæus, ſaid to have been preſent at years only; the decays then of mankind would be too faſt: but at the middle rate mentioned the balance is nearly even, and life and death keep an equal pace. Which equality is ſo great and harmonious, and ſo manifeſt an inſtance of the divine management, that I ſhall ſpend ſome remarks upon it.

It appears from our beſt accounts of theſe matters that in our European parts[r], and, I believe the

---

our Saviour's crucifixion; although very ſerious ſtories are told of his being ſeen at Antwerp, and in France, about the middle of the laſt century but one; and before in anno 1542, converſed with by Paul of Eitſen, biſhop of Sleſwick; and before that viz. in 1228, ſeen and converſed with by an Armenian archbiſhop's gentleman; and by other at other times.

If the reader hath a mind to ſee more examples, he may meet with ſome of all ages, in the learned Hakewill's Apol. p. 181. where he will alſo find that learned author's opinion of the cauſes of the brevity and length of human life. The brevity thereof he attributeth to a too tender education, ſucking ſtrange nurſes, too haſty marriages; but above all, to luxury, high ſauces, ſtrong liquors, &c. The longevity of the ancients he aſcribes to temperance in meat and drink, anointing the body, the uſe of ſaffron and honey, warm clothes, leſſer doors and windows, leſs phyſic, and more exerciſe.

[r] The proportions which marriages bear to births, and births to burials in diverſe parts of Europe, may be ſeen at an eaſy view in this table.

the ſame is throughout the world; that, I ſay, there is a certain rate and proportion in the propagation of mankind : ſuch a number

Names of the Places.	Marriages to births : as	Births to burials : as
England in general - -	1 to 4,63	1 12 to 1
London - - - -	1 to 4	1 to 1,1
Hantſhire, from 1569, to 1658 -	1 to 4	1,2 to 1
Tiverton in Devonſh. 1560, to 1649	1 to 3,7	1,26 to 1
Cranbrook in Kent 1560, to 1649	1 to 3,9	1,6 to 1
Aynho in Northamptonſh. for 118 years	1 to 6	1,6 to 1
Leeds in Yorkſhire, for 122 years	1 to 3,7	1,07 to 1
Harwood in Yorkſhire, for 57 years	1 to 3.4	1,23 to 1
Upminſter in Eſſex, for 100 years	1 to 4,6	1,08 to 1
Frankfort on the Main, in 1695	1 to 3,7	1,2 to 1
Old, middle, and lower Marck in 1698	1 to 3,7	1,9 to 1
Domini. of the K. of Pruſſia in 1698	1 to 3,7	1,5 to 1
Breſlaw in Sileſia, from 1687, to 1691		1,6 to 1
Paris, in 1670, 1671, 1672.	1 to 4,7	1 to 1,6

Which table I made from major Graunt's obſervations on the bills of mortality; Mr. King's obſervations in the firſt of Dr. Davenant's eſſays; and what I find put together by my ingenious friend, Mr. Lowthorp, in his Abridgement vol. 3. p. 668, and my own regiſter of Upminiſter. That from Aynho's regiſter in Northamptonſhire, I had from the preſent rector, the learned and ingenious Mr. Waſſe: and I was promiſed ſome accounts from the north, and diverſe other parts of this kingdom; but have not yet received them; only thoſe of Leeds and Harwood in Yorkſhire, from my curious and ingenious friend Mr. Thoreſby.

marry [s], ſo many are born, ſuch a number die in proportion to the number of perſons in every nation, country, or pariſh. And as to births, two things are very conſiderable: one is the proportion of males and females [t], not in a wide proportion, not an uncertain, accidental number at all adventures; but nearly equal. Another thing is, that a few more are born than appear to die, in any certain place[*]. Which is an admirable proviſion for the ex-

---

[s] The preceding table ſhews, that marriages, one with another, do each of them produce about four births; not only in England, but in other parts of Europe alſo.

And by Mr. King's eſtimate, the beſt computations I imagine of any, being derived from the beſt accoonts; ſuch as the marriage, birth, burial-act, the poll-books, &c. by his eſtimate, I ſay, about 1 in 104 marry. For he judgeth the number of the people of England to be about five millions and a half; of which about 41000 annually marry. As to what might be farther remarked concerning marriages, in regard of the rites and cuſtoms of ſeveral nations, the age to which diverſe nations limited marriages &c. it would be endleſs, and too much out of the way to mention them; I ſhall only therefore, for the reader's diverſion take notice of the jeer of Lactantius, 'Quare apud poetas ſalaciſſimus Jupiter deſiit liberos tollere? Utrum ſexagenarius factus, et ei lex Papia fibulam impoſuit?' Lact. Inſtit. l. 1 c. 16. By which lex Papia, men were prohibited to marry after 60, and women after 50 years of age.

[t] Major Graunt (whoſe concluſions ſeem to be well grounded) and Mr. King, diſagree in the proportions they aſſign to males and females. This latter makes in London, 10 males to 13 females; in other cities and market towns 8 to 9: and in the

---

the villages and hamlets, 100 males to 99 females. But major Graunt, both from the London and country bills, ſaith, there are 14 males to 13 females: from whence he juſtly infers 'That the Chriſtian religion, prohibiting polygamy, is more agree-'able to the law of nature than Mahometiſm, and others that 'allow it,' chap. 8.

This proportion of 14 to 13, I imagine is nearly juſt, it being agreeable to the bills I have met with as well as thoſe in Mr. Graunt. In the 100 years, for example, of my own pariſh-regiſter, although the burials of males and females were nearly equal, being 636 males, and 623 females, in all that time; yet there were baptized 709 males, and but 675 females, which is 13 females to 13,7 males. Which inequality ſhews, not only, that one man ought to have but one wife; but alſo that every woman may, without polygamy, have an huſband, if ſhe doth not bar herſelf by the want of virtue, by denial, &c. Alſo this ſurpluſage of males is very uſeful for the ſupplies of war the ſeas and other ſuch expences of the men above the women.

That this is a work of the divine providence, and not a matter of chance, is well made out by the very laws of chance, by a perſon able to do it, the ingenious and learned Dr. Arbuthnot. He ſuppoſeth Thomas to lay againſt John, that for eighty two years running, more males ſhall be born than females; and giving all allowances in the computation to Thomas's ſide, he makes the odds againſt Thomas, that it doth not happen ſo, to be near five millions of millions, of millions of millions, to one; but for ages of ages, according to the world's age, to be near an infinite number to one againſt Thomas. Vide Phil. Thanſ. N° 338.

[*] The foregoing table ſhews, that in England in general, fewer die than are born there being but 1 death to 1 $\frac{12}{100}$ births.

But

traordinary emergencies and occaſions of the world; to ſupply unhealthful places, where death out-runs life; to make up the ravages of great plagues and diſeaſes, and the depredations of war, and the ſeas; and to afford a ſufficient number for colonies in the unpeopled parts of the earth. Or, on the other hand, we may ſay, that ſometimes thoſe extraordinary expences of mankind may be not only a juſt puniſhment of the ſins of men; but alſo a wiſe means to keep the balance of mankind even; as one would be ready

to

But in London more die than are born. So by D. Davenant's table, the cities likewiſe and market-towns bury 1 $\frac{7}{100}$ to one birth. But in Paris they out-do London, their deaths being 1 $\frac{1}{2}$ to one birth: the reaſon of which I conceive is, becauſe their houſes are more crouded than in London. But in the villages of England, there are fewer die than are born, there being but 1 death to 1 $\frac{17}{100}$ births. And yet major Graunt, and Dr. Davenant, both obſerve that there are more breeders in London and the cities and market-towns, than are in the country notwithſtanding the London births are fewer than the country; the reaſon of which ſee in Graunt, c. 7. and Davenant, ubi ſup p. 21.

The laſt remark I ſhall make from the foregoing table, ſhall be, that we may from thence judge of the healthfulneſs of the places there mentioned. If the year 1698 was the mean account of the three Marcks, thoſe places bid the faireſt for being moſt healthful; and next to them, Aynho and Cranbrook for Engliſh towns.

* Quid

ed by ſome other means? That the world ſhould be as well, or better ſtocked than now it is, in 1656 years (the time between the cre-

hunt with the emperor Henry II. and bring but few ſervants, brought only one ſervant, and his thirty-two ſons. To theſe many others might be added; but one of the moſt remarkable inſtances I have any where met with, is that of Mrs. Honywood, mentioned by Hakewell Cambden, and other authors; but having now before me the names, with ſome remarks, (which I received from a pious neighbouring deſcendant of the ſame Mrs. Honywood) I ſhall give a more particular account then they. Mrs. Mary Honywood was daughter, and one of the co-heireſſes of Robert Atwaters, Eſq; of Lenham in Kent. She was born in 1527, married in February 1543, at ſixteen years of age, to her only huſband Robert Honywood, of Charing in Kent, Eſq; She died in the ninty-third year of her age, in May 1620. She had ſixteen children of her own body, ſeven ſons and nine daughters; of which one had no iſſue, three died young, and the youngeſt was ſlain at Newport-battle, June 20, 1600. Her grand-children in the ſecond generation, were 114; in the third, 228; and 900 in the fourth generation. So that ſhe could ſay the ſame that the diſtich doth, made of one of the Dalburg's family of Baſil:

1 2 3 4
Mater ait natæ dic natæ, filia natam
5 6
Ut moneat, natæ, plangere filiolam:
1 2 3 4
Riſe up daughter, and go to thy daughter, for her daughter's
5 6
Daughter hath a daughter

Mrs. Honywood was a very pious woman, afflicted, in her declining age, with deſpair, in ſome meaſure; concerning which, ſome divines once diſcourſing with her, ſhe in a paſſion ſaid, ‘ She was

‘ as

creation and the flood; this) we will ſuppoſe may be done by the natural method of each ſpecies doubling or increaſe; but in double that number of years, or at this diſtance from the flood, of 4000 years, that the world ſhould not be over-ſtocked, can never be made out, without allowing an infinite providence.*

I conclude then this obſervation with the pſalmiſt's words, Pſal. civ. 29, 30. 'Thou
'hideſt thy face, all creatures are troubled;
'thou takeſt away their breath, they die, and
'return to their duſt. Thou ſendeſt forth thy
"ſpirit they are created; and thou reneweſt
'the face of the earth.'

---

* as certainly damned as this glaſs is broken,' (throwing a Venice glaſs aginſt the ground, which ſhe had then in her hand.) But the glaſs eſcaped breaking, as credible witneſſes atteſted.

CHAP. XI.

OF THE FOOD OF ANIMALS.

THE preceding reflection of the pſalmiſt mindeth me of another thing in common to animals, that pertinently falleth next under conſideration, which is, the appointment of food, mentioned in verſe 27, 28, of the laſt cited Pſalm civ. 'Theſe [creatures] wait all 'upon thee, that thou mayeſt give them their 'meat in due ſeaſon. That thou giveſt them, 'they gather; thou openeſt thy hand they 'are filled with good.' The ſame is again aſſerted in Pſal. cxlv. 15. 16. 'The eyes of 'all wait upon thee, and thou giveſt them 'their meat in due ſeaſon. Thou openeſt thy 'hand and ſatisfieſt the deſire of every living 'thing.'

What the pſalmiſt here aſſerts, affords us a glorious ſcene of the divine providence and management. Which (as I have ſhewed it to concern itſelf in other leſſer things;) ſo we may preſume doth exert itſelf particularly in ſo grand an affair as that of food, whereby the animal world ſubſiſts: and this will be manifeſted, and the pſalmiſt's obſervations exemplified, from theſe ſix following particulars

I. From the ſubſiſting and maintaining ſuch a large number of animals, throughout all parts of the world.

II. From the proportionate quantity of food to the eaters.

III. From the variety of food ſuited to the variety of animals: or, the delight which various animals have in different food.

IV. From the peculiar food which peculiar places afford to the creatures ſuited to thoſe places.

V. From the admirable and curious apparatus made for the gathering, preparing, and digeſtion of the food.

VI. And laſtly, From the great ſagacity of all animals, in finding out and providing their food.

I. It is a great act of the divine power and wiſdom, as well as goodneſs, to provide food for ſuch a world of animals [y], as every where poſſeſs the terraqueous globe; on the dry land, and in the ſea and waters; in the torrid and frozen zones, as well as the temperate. That the temperate climates, or at leaſt the fertile vallies, and rich and plentiful regions of the earth, ſhould afford ſubſiſtence to many animals may appear leſs wonderful perhaps; but that in all other the moſt unlikely places for ſupplies, ſufficient food ſhould be afforded for ſuch a prodigious number, and ſo great variety of beaſts, birds, fiſhes, and inſects, is owing to that being, who hath as wiſely adapted their bodies to their place and food, as well and carefully provided food for their ſubſiſtence there.

---

[y] 'Paſtum animantibus large et copioſe natura eum: quod 'cuique aptus erat, comparavit.' Cic, de Nat. Deor. l. 2. c. 47.

'Ille deus eſt.——qui per totum orbem armenta dimiſit, qui 'gregibus ubique paſſim vagantibus pabulum præſtat.' Senec. de Benef. l. 4. c. 6.

But I ſhall leave this conſideration, becauſe it will be illuſtrated under the following points; and proceed,

II. To conſider the adjuſtment of the quantity of food, in proportion to the eaters. In all places there is generally enough; nay, ſuch a ſufficiency, as may be ſtiled a plenty; but not ſuch a ſuperfluity as to waſte and corrupt and thereby annoy the world. But that which is particularly remarkable here, is that among the great variety of foods, the moſt uſeful is the moſt plentiful, moſt univerſal, eaſieſt propagated, and moſt patient of weather and other injuries. As the herbacious eaters, for inſtance, are many, and devour much; ſo the dry-land ſurface we find every where almoſt naturally carpeted over with graſs, and other agreeable wholeſome plants; propagating themſelves in a manner every where, and ſcarcely deſtroyable by the weather, the plough, or any part. So likewiſe for grain, eſpecially ſuch as is moſt uſeful, how eaſily is it cultivated, and what a large increaſe doth it produce! Pliny's example of wheat[z], is a ſufficient inſtance in this matter;

---

[z] ‘Tritico nihil eſt fertilius: hoc ei natura tribuit, quoniam eo maxime alat hominem: utpote cum e modio, ſi ſit ap- tum

which, as that curious heathen obſerves, being principally uſeful to the ſupport of man, is eaſily propagated, and in great plenty: and an happy faculty that is of it, that it can bear either extremes of heat or cold, ſo as ſcarce to refuſe any clime.

III. Another wiſe proviſion the Creator hath made relating to the food of animals, is, that various animals delight in various food [a]; ſome in graſs and herbs; ſome in grain and ſeeds: ſome in fleſh; ſome in inſects; ſome in this [b],

ſome

‘ tum ſolum——150 modii reddantur. Miſit D. Auguſto procurator—ex uno grano, vix credibile dictu, 400 paucis minus germina. Miſit et Neroni ſimiliter 340 ſtipulas ex uno grano.’ Plin. Nat. Hiſt. l. 18, c. 10.

[a] ‘ Sed illa quanta benignitas naturæ quod tam multa ad veſcendum, tam varia, tam jucunda gignit: neque ea uno tempore anni. ut ſemper et novitate delectemur et copia.’ Cic. de Nat. Deor. l. 2. c. 53.

[b] Swammerdam obſerves of the Ephemeran-worms, that their food is clay and that they make their cells of the ſame. Upon which occaſion he ſaith of moths, that eat wooll and fur, ‘ There are two things very conſiderable, 1. That the cells they make to themſelves, wherein they live, and with which as their houſe, tortoiſe-like, they move from place to place, they make of the matter next at hand. 2. That they feed alſo on the ſame, therefore when you find their cells, or rather coats or caſes, to be made of yellow, green, blue, or black cloth, you will alſo find their dung of the ſame colour.’ Swam. Ephem. vita, publiſhed by Dr. Tyſon, chap. 3.

ſome in that; ſome more delicate and nice; ſome voracious and catching at any thing. If all delighted in, or ſubſiſted only with one ſort of food, there would not be ſufficient for all; but every variety chuſing various food, and, perhaps, abhorring that which others like, is a great and wiſe means that every kind hath enough, and oftentimes ſomewhat to ſpare.

It deſerves to be reckoned as an act of the divine appointment, that what is wholeſome food to one, is nauſeous, and as a poiſon to another; what is a ſweet and delicate ſmell and taſte to one, is foetid and loathſome to another: by which means all the proviſions the globe affords are well diſpoſed of. Not only every creature is well provided for, but a due conſumption is made of thoſe things that otherwiſe would encumber the world, lie in the way, corrupt, rot, ſtink, and annoy, inſtead of cheriſhing and refreſhing it. For our moſt uſeful plants, grain and fruits, would mould and rot; thoſe beaſts, fowls, and fiſhes, which are reckoned among the greateſt dainties, would turn to carrion, and poiſon us: nay, thoſe animals which are become carrion, and many other things that are noiſome both on the dry-land, and in the waters, would be great annoyances and breed diſeaſes, was it not for the proviſion which the infinite orderer of the world hath made, by cauſing theſe things to be ſweet, pleaſant, and wholſome food to ſome creature or other, in the place where thoſe things fall: to dogs, ravens, and other voracious animals, for inſtance, on the earth; and to rapacious fiſhes, and other creatures inhabiting the waters.

Thus is the world, in ſome meaſure, kept ſweet and clean, and at the ſame time, diverſe ſpecies of animals ſupplied with convenient food. Which providence of God, particularly in the ſupplies afforded the ravens, is divers times taken notice of in the ſcriptures [c]; but whether for the reaſons now hinted, or any other ſpecial reaſons, I ſhall not inquire. Thus our Saviour Luke xii. 24. 'Conſider the ravens; for they 'neither ſow nor reap, which neither have ſtore-'houſe, nor barn, and God feedeth them.' It 'is a manifeſt argument of the divine care and providence, in ſupplying the world with food and neceſſaries, that the ravens, accounted as unclean and little regarded by man, deſtitute of ſtores, and that live by accidents, by what falleth here and there; that ſuch a bird, I ſay ſhould be provided with ſufficient food; eſpecially if that be true which Ariſtotle[d], Pliny[e], and Ælian[f] report, of their unnatural affection and cruelty to their young: 'That they expel them their neſts as ſoon they can fly, and then drive them out of the country.'

---

[c] Job xxxviii. 41. Pſalm cxlvii. 9.

Thus having conſidered the wiſe appointment of the Creator, in ſuiting the variety of food, to variety of animals: let us in the

IV. Place, Take a view of the particular food, which particular places afford to the creatures inhabiting therein.

It hath been already obſerved[g], that every place on the ſurface of the terraqueous globe, is ſtocked with proper animals, whoſe organs of life and action are curiouſly adapted to each reſpective place. Now, it is an admirable act of the divine providence, that every place affords a proper food to all the living creatures therein. All the various regions of the world, the different climates [h], the various ſoils, the ſeas, the waters, nay, our very putrefactions and moſt naſty places about the globe, as they are inhabited by ſome or other animal, ſo they produce ſome proper food or other, affording a comfortable ſubſiſtence to the creatures living there. I might, for inſtances [i] of this bring the great variety of herbs, fruits, and grains on the earth, the large ſwarms of inſects in the air, with every other food of the creatures reſiding in the earth, or flying in the air. But I ſhall ſtop at the waters, becauſe the pſalmiſt, in the forecited civth Pſalm ſpeaks with relation to the ſpecial proviſion for the inhabitants of the waters ; and alſo by reaſon that many land-animals have their chief maintenance from thence.

---

[d] Ariſtot. l. 9. c. 31: Hiſt. Animal.

[e] Pliny affirms this of the crow as well as raven; Cæteræ omnes [i. e. cornices] ex eodem genere pellunt nidis pullos, ac volare cogunt, ſicut et corvi, qui——robuſtos ſuos foetus fugant longius.' Nat. Hiſt. l. 10 c. 12.

[f] Var. Hiſt.

[g] Chap. 9.

---

[h] ‘Admiranda naturæ diſpenſatio eſt, ut aliter, alioque, modo, tempore, et induſtria colatur terra ſeptentrionalis, aliter Æthiopia, &c. Quoad aquilonares, hoc certum eſt, in pleriſque agris Veſtrogothorum, parte objecta meridionali plagæ hordeum ſpatio 36 dierum a ſemine projecto maturum colligi hoc eſt, a fine Junii uſque medium Auguſti, aliquando celerius. Ea namque maturitas ex ſoli, natura, aeriſque clementia, ac humore lapillorum fovente radices, ſoleque torrente, neceſſario provenit; ut ita naſcatur, ac maturetur, taleſque ſpicæ ſex ordines in numero ariſtæ habent.’ Ol. Mag. Hiſt. l. 15. c. 8. ‘Prata et paſcua tanta luxuriant graminum ubertate ac diverſitate, ut neceſſum ſit inde arcere jumenta, ne nimio herbarum eſu crepent,’ &c. Id. ib. l. 19. c. 36.

[i] Among the many noble contrivances for food, I cannot but attribute that univerſal aliment, bread, to the revelation, or at

that

Now, one would think, that the waters were a very unlikely element to produce food for ſo great a number of creatures, as have their ſubſiſtence from thence. But yet how rich a promptuary is it, not only to large multitudes of fiſhes, but alſo to many amphibious quadrupeds, inſects, reptiles, and birds ! From the largeſt leviathan, which the pſalmiſt ſaith ‘ playeth

at leaſt the inſpiration of the Creator and conſervator of mankind ; not only becauſe it is a food uſed in all, or moſt parts of the world ; but eſpecially becauſe it is of incomparable uſe in the great work of digeſtion, greatly aſſiſting the ferment, or whatever cauſes the digeſtion of the ſtomach. Of which take this example from the noble Mr. Boyle. ‘ He extracted a menſtruum from bread alone, that would work on bodies more ‘ compact than many hard minerals, nay, even on glaſs itſelf, ‘ and do many things that aqua-fortis, could not do——Yet by in the ſeas [k],' to the ſmalleſt mites in the lakes and ponds, all are plentifully provided for; as is manifeſt from the fatneſs of their bodies and the gaiety of their aſpect and actions.

And the proviſion which the Creator hath made for this ſervice in the waters is very obſervable; not only by the germination of diverſe aquatic plants there, but particularly by appointing the waters to be the matrix of many animals, particularly of many of the inſect kind, not only of ſuch as are peculiar to the waters, but alſo of many appertaining to the air and the land, who by their near alliance to the waters, delight to be about them, and by that means become a prey, and plentiful food to the inhabitants of the waters. And beſides theſe, what prodigious ſhoals do we find of minute animals, even ſometimes diſcolouring the

---

'no means was this ſo corroſive a liquor as aqua-fortis, or as the 'other acid menſtruum.' See the ingenious and learned Dr. Harris's Lex. Tech. verbo Menſtruum, where the way of preparing it may be met with.

[k] Pſalm civ. 26.

waters [1] ! Of theſe (not only in the water, but in the air and on land) I have always thought there was ſome more than ordinary uſe intended by the all-wiſe Creator. And having bent many of my obſervations that way, I have evidently found it accordingly to be. For be they never ſo numberleſs or minute, thoſe animals ſerve for food to ſome creatures or other. Even thoſe animalcules in the waters, diſcoverable only with good microſcopes, are a repaſt to others there

---

[1] The inſects that, for the moſt part, diſcolour the waters, are the ſmall inſects of the ſhrimp-kind, called by Swammerdam, ‘ Pulex aquaticus arboreſcens.’ Theſe I have often ſeen ſo numerous in ſtagnating waters in the ſummer months, that they have changed the colour of the waters to a pale or deep red, ſometimes a yellow, according to the colour they were of. Of theſe Swammerdam hath a pretty ſtory told him by Dr. Florence Schuyl, viz. ‘ Se aliquando ſtudiis intentum, magno quodam et ‘ horrifico rumore fuiſſe turbatum, et ſimul ad cauſam ejus inquirendam excitatum; verum ſe vix eum in finem ſurrexiſſe, ‘ cum ancilla ejus poene exanimis adcurreret, et multo cum ſingultu referret, omnem Lugduni [Batavorum] aquam eſſe mutatam in ſanguinem.’ The cauſe of which upon examination, he found to be only from the numerous ſwarms of thoſe pulices. Vide Swamm. Hiſt. Inſect. p. 70.

The cauſe of this great concourſe and appearance of thoſe little inſects, I have frequently obſerved to be to perform their coit : which is commonly about the latter end of May, and in June. At that time they are very venereous, friſking and catching there, as I have often with no leſs admiration than pleaſure ſeen [m].

But now the uſual objection is, that neceſſity maketh [k]. Animals muſt be fed, and they make

---

at one another; and many of them conjoined tail to tail with their bellies inclined one towards one another.

At this time they alſo change their ſkin or ſlough, which I conceive their rubbing againſt one another mightily promoteth. And what if at this time they change their quaters! See book viii. chap. 4.

Theſe ſmall inſects, as they are very numerous, ſo are food to many water-animals. I have ſeen not only ducks ſhovel them up as they ſwin along the waters but divers inſects alſo devour them, particularly ſome of the middle-ſized ſquillæ aquaticæ, which are very voracious inſects.

[m] Beſides the pulices laſt mentioned, there are in the waters other animalcules very numerous, which are ſcarce viſible without a microſcope. In May, and the ſummer months, the green ſcum on the top of ſtagnating waters, is nothing elſe but prodigious numbers of theſe animalcules; ſo is likewiſe the green colour in them, when all the water ſeem green. Which animalcules, in all probability, ſerve for food to the pulices aquatici, and other the minuter animals of the waters. Of which I gave a pregnant inſtance in one of the nymphæ of gnats to my friend the late admirable Mr. Ray, which he was pleaſed to publiſh in the laſt edition of his Wiſd. of God in the Creat. p. 430.

[k] Nil adeo quoniam natum eſt in corpore, ut uti

Poſſemus,

make uſe of what they find: in the deſolate regions, and in the waters, for inſtance, they
feed

Poſſemus, ſed quod natum eſt id procreat uſum.

And afterwards

Propterea capitur cibus, ut ſuffulciat artus
Et recreet vireis, intendatus, atque patentem
Per membra ac venas ut amorem obturet edendi.

And after the ſame manner he diſcourſeth of thirſt, and divers other things. Vide Lucret. l. 4. v. 831, &c.

Againſt this opinion of the Epicureans, Galen ingeniouſly argues in his diſcourſe about the hand. 'Non enim manus ipſæ (ſaith he) hominem artes docuerunt, ſed ratio, Manus autem ipſæ ſunt artium organa; ſicut lyra muſici——Lyra muſicam non docuit, ſed eſt ipſius artifex per eam, qua præditus eſt rationem: agere autem non poteſt ex arte abſque organis ita, et una quælibet anima facultates quaſdem a ſua ipſius ſubſtantia obtinet——Quod autem corporis particulæ animam non impellunt,—manifeſte videre licet, ſi animalia recenter nata conſideres, quæ quidem prius agere conantur, quam perfectas habeant particulas. Ego namque bovis, vitulum cornibus petere conantem ſæpenumero vidi, antequam ei nata eſſent cornua; et pullum equi calcitrantem, &c. Omne enim animal ſuæ ipſius animæ facultates, ac in quos uſus partes ſuæ polleant maxime, nullo doctore, præſentit.——Qua igitur ratione dici poteſt, animalia partium uſus a partibus doceri, cum et antequam illas habeant hoc cognoſcere videantur? Si igitur ova tria acceperis, unum aquilæ, alterum anatis, reliquum ſerpentis et calore modico foveris, animaliaque excluſeris; illa quidem alis volare conan

'tia

feed upon what they can come at; but, when in greater plenty they pick and chuſe.

But this objection hath been already in ſome meaſure anſwered by what hath been ſaid; which plainly argues deſign, and a ſuper-intending wiſdom, power and providence in this ſpecial buſineſs of food. Particularly the different delight of diverſe animals in different food, ſo that what is nauſeous to one, ſhould be dainties to another, is manifeſt argument, that the allotment of food is not a matter of mere chance, but entailed to the very conſtitution and nature of animals; that they chuſe this, and refuſe that, not by accident, or neceſſity, but becauſe the one is a proper food, agreeable to their conſtitution, and ſo appointed by the infinite contriver of their bodies; and the other is diſagreeable and injurious to them.

But all this objection will be found frivolous, and the wiſdom and deſign of the great Creator will demonſtratively appear, if we take a ſurvey.

V. Of the admirable and curious apparatus in all animals, made for the gathering, preparing

ing and digeſtion of their food. From the very firſt entrance, to the utmoſt exit of the food, we find every thing contrived made and diſpoſed with the utmoſt dexterity of art, and curiouſly adapted to the place the animal liveth in, and the food it is to be nouriſhed with.

Let us begin with the mouth. And this we find in every ſpecies of animals, nicely conformable to the uſe of ſuch a part; neatly ſized and ſhaped for the catching of prey, for the gathering or receiving food [1], for the formation of ſpeech

---

'ante quam volare poſſint; hoc autem revolvi videbis, et ſerpere affectans, quamvis molle adhuc et invalidum fuerit:

'Et ſi dum perfecta erunt, in una eademque domo nutriveris, deinde ad locum ſubdialem ducta miſeris, aquila quidem ad ſublime; anas autem in paludem;—ſerpens vero ſub terra irrepet—Animalia quidem mihi videntur natura magis quam ratione artem aliquam [τεχνικα artificioſa] exercere: apes fingere alveolas, &c. Galen de Uſu Part. l. 11. c. 3.

[1] 'Alia dentibus prædantur, alia unguibus alia roſtri aduncitate carpunt, alia latitudine [ejuſdem) ruunt, alia acumine excavant alia ſugunt alia lambunt ſorbent, mandunt vorant Nec

ſpeech, and every other ſuch like uſe [m]. In ſome creatures it is wide and large, in ſome little and narrow; in ſome with a deep inciſure up into the head [n], for the better catching and holding of prey, and more eaſy com-

---

‘ Nec minor varietas in pedum miniſterio ut rapiant diſtrahant, ‘ teneant, premant, pendeant, tellurem ſcabere non ceſſent. Plin. Nat. Hiſt. l. 10. c. 71.

[m] Becauſe it would be tedious to reckon up the bones, glands muſcles, and other parts belonging to the mouth, it ſhall ſuffice to obſerve, that, for the various ſervices of man's mouth, beſides the muſcles in common with other parts, there are five pair, and one ſingle one proper to the lips only, as Dr. Gibſon reckons them, but my moſt diligent and curious friend the late Mr. Cowper, diſcovered a ſixth pair. And accordingly Dr. Drake reckons ſix pair and one ſingle one proper to the lips, l. 3. c. 13.

[n] Galen deſerves to be here conſulted, who excellently argues againſt the caſual concourſe of the atoms of Epicurus and Aſclepiades, from the provident and wiſe formation of the mouths of animals, and their teeth anſwerable thereto. In man, his mouth without a deep inciſure, with only one canine tooth on a ſide, and flat nails becauſe, ſaith he, ‘ Hic natura certo ſciebat, ſe animal manſuetum ac civile effingere, cui robur et vires ‘ eſſent ex ſapientia, non ex corporis fortitudine.’ But for lions, wolfs, and dogs, and all ſuch as are called Καρχαρόδοντες, (or having ſharp, ſerrated teeth) their mouths are large, and deep cut: teeth ſtrong and ſharp, and their nails ſharp, large, ſtrong, and round, accommodated to holding and tearing. Vide Galen, de Uſu Part. l. 11. c. 9.

minution of hard, large troubleſome food; in others with a much ſhorter inciſure, for the gathering and holding of herbacious food.

In inſects it is very notable. In ſome forcipated, to catch hold and tear their prey[o]. In ſome aculeated, to pierce and wound animals [p], and ſuck their blood. And in others ſtrongly ly rigged with jaws and teeth, to gnaw and ſcrape out their food, to carry burdens [q] to perforate the earth, yea, the the hardeſt wood,

---

[o] Among inſects, the ſquillae aquaticæ, as they are very rapacious, ſo are accordingly provided for it: particularly the 'ſquilla aquatica maxima recurva,' as I call it, who hath ſomewhat terrible in its very aſpect and in its poſture in the water, eſpecially its mouth, which is armed with long, ſharp hooks, with which it boldly, and greedily catcheth any thing in the waters even one's fingers. Whan they have ſeized their prey, they will ſo tenaciouſly hold it with their forcipated mouth, that they will not part therewith, even when they are taken out of the waters, and jumbled about in one's hand. I have admired at their peculiar way of taking in their food; which is done by piercing their prey with their forcipes which are hollow, and ſucking the juice thereof through them.

The ſquilla here mentioned is the firſt and ſecond in Mouffet's Theat. Inſect. l. 2. c. 37.

[p] For an inſtance of inſects endued with a ſpear, I ſhall for its peculiarity pitch upon one of the ſmalleſt, if not the very ſmálleſt of all the gnat-kind, which I call, 'Culex minimus nigricans maculatus ſanguiſuga.' Among us in Eſſex, they are called nidiots; by Mouffet Midges. It is about one tenth of an inch, or ſomewhat more long with ſhort antennæ, plain in the

---

the female in the male feathered ſomewhat like a bottle-bruſh. It is ſpotted with blackiſh ſpots, eſpecially on the wings, which extend a little beyond the body. It comes from a little ſlender eel-like worm, of a dirty white colour, ſwimming in ſtagnating waters by a wrigling motion as in Fig. 5.

Its aurelia is ſmall with a black head, little ſhort horns, a ſpotted ſlender, rough belly. Fig. 6. It lies quietly on the top of the water, now and then gently wagging itſelf, this way and that.

Theſe gnats are greedy blood ſuckers and very troubleſome where numerous; as they are in ſome places near the Thames particularly in the Breach-waters that have lately fallen near us, in the pariſh of Dagenham; where I found them ſo vexatious that I was glad to get out of thoſe marſhes. Yea, I have ſeen horſes ſo ſtung with them, that they have had drops of blood all over their bodies, where they were wounded by them.

I have given a figure (in Fig. 7.) and more particular deſcription of the gnats becauſe although it be common, it is no where taken notice of by any author I know, except Mouffet, who, I ſuppoſe, means theſe gnats, which he calls Midges, c. 13. p. 82.

[q] Hornets and waſps have ſtrong jaws, toothed, wherewith they can dig into fruits, for their food; as alſo gnaw and ſcrape wood, whole mouthfuls of which they carry away to make their combs. Vide infra, chap. 13.

yea, even ſtones themſelves, for houſes [r] to themſelves, and neſts for their young.

And laſtly, in birds it is no leſs remarkable. In the firſt place, it is neatly ſhaped for piercing the air, and making way for the body through the airy regions. In the next place, it is hard and horny, which is a good ſupplement for the want of teeth, and cauſeth the bill to have the uſe and ſervice of the hand. Its hooked form is of great uſe to the rapacious kind [ſ], in catching and holding their prey, and in the comminution thereof by tearing; to others it is no leſs ſerviceable to their climbing, as well as neat and nice comminution of their food [s]. Its extraordinary length and ſlenderneſs is very uſeful to ſome, to ſearch and grope for their food in mooriſh places [t]; as its length and breadth is to others to hunt and ſearch in muddy places [u]: and the contrary form, namely, a thick, ſhort, and ſharp-edged bill is as uſeful to other birds, who have occaſion to huſk and flay the grains they ſwallow. But it would be endleſs, and tedious, to reckon up all the various ſhapes, and commodious mechaniſm of all; the ſharpneſs and ſtrength of thoſe who have occaſion to perforate wood and ſhells,[x] the ſlenderneſs and neatneſs of ſuch as pick up ſmall inſects; the croſs-form of ſuch as break up fruits[y]; the compreſſed form of others[z], with with many other curious and artificial forms, all ſuited to the way of living, and peculiar occaſions of the ſeveral ſpecies of birds. Thus much for the mouth.

---

[r] Monſieur de la Voye tells of an antient wall of free ſtone in the Benedictines-Abbey, at Caen in Normandy, ſo eaten with worms, that one may run one's hand into moſt of the cavities: that theſe worms are ſmall and black, lodging in a greyiſh ſhell; that they have large flattiſh heads a large mouth, with four black jaws: &c. Phil. Tranſ. N° 18.

[ſ] 'Pro iis [labris] cornea et acuta volucribus roſtra Eadem 'rapto viventibus adunca; collecto, recta; herbas ruentibus li-'mumque lata, ut ſuum generi. Jumentis vice manus ad col-'ligenda pabula: ora apertiora laniatu viventibus.' Plin. Nat. Hiſt. l. 11. c. 37.

---

[s] Parrots have their bills nicely adapted to theſe ſervices, being hooked for climbing and reaching what they have occaſion for; and the lower jaw being completely fitted to the hooks of the upper, they can as minutely break their food, as other animals do with their teeth.

[t] Thus in woodcocks, ſnipes, &c. who hunt for worms in mooriſh ground, and, as Mr. Willoughby ſaith, live alſo on the fat unctuous humour they ſuck out of the earth. So alſo the bills of curlews, and many other ſea-fowls, are very long, to enable them to hunt for the worms, &c. in the ſands on the ſea-ſhore, which they frequent.

[u] Ducks, geeſe, and diverse others, have ſuch long broad bills, to quaffer and hunt in water and mud; to which we may reckon the uncouth bill of the ſpoon-bill: but that which deſerves particular obſervation in the birds named in theſe two laſt notes is, the nerves going to the end of their bills, enabling them to diſcover their food out of ſight; of which ſee book vii. chap. 2.

Let us next take a ſhort view of the teeth[a]. In which their peculiar hardneſs

---

[x] The picus viridis, or green wood-ſpite, and all the wood peckers, have bills curiouſly made for digging wood, ſtrong, hard, and ſharp. A neat ridge runs along the top of the green woodpecker's bill as if an artiſt had deſigned it for ſtrength and neatneſs.

[y] The loxia, or croſs-bill, whoſe bill is thick and ſtrong with the tips croſſing one another; with great readineſs breaks open fir-cones, apples, and other fruit, to come at their kernels, which are its food, as if the croſſing of the bill was deſigned for this ſervice.

[z] The ſea-pie hath a long, ſharp, narrow bill, compreſſed ſide-ways, and every way ſo well adapted to the raiſing limpets from the rocks, which are its chief, if not only food, that nature, or rather the author of nature ſeems to have framed it purely for that uſe.

[a] 'Thoſe animals which have teeth on both jaws have but 'one ſtomach: but moſt of thoſe which have no upper teeth, 'or none at all, have three ſtomachs; as in beaſts, the paunch, 'the read, and the feck; and in all granivorous birds, the crop

[b] is remarkable, their growth [c] alſo, their firm inſertion and bandage in the gums and jaws, and their various ſhape and ſtrength, ſuited to their various occaſions and uſe [d]; the foremoſt weak and

---

‘ the echinus, and the gizard. For as chewing is to an eaſy digeſtion, ſo is ſwallowing whole to that which is more laborious.’ Dr. Grew's Coſmol. Sacr. c. 5. ſect 24.

[b] J. Peyer ſaith, the teeth are made of convolved ſkins hardened; and if we view the grinders of deer, horſes, ſheep &c. we ſhall find great reaſon to be of his mind. His obſervations are, ‘ Mirum autem eos [i. e. dentes) cum primum e pelliculis imbricatim convolutis et muco viſcido conſtarent, in tantam dirigeſcere ſoliditatem, quæ oſſa cuncta ſuperet. Idem fit etiam in oſſiculis ceraſorum, &c.—Separatione facta, per membranas conditur magna locellis, quos formant laminæ tenues ac duriuſculæ ad dentis figuram antea divinitus compoſitæ J. Peyer Merycol. l. 2. c. 8.

[c] ‘ Qui autem (i. e. dentes) renaſcuntur, minime credendi ſunt a facultate aliqua plaſtica brutorum denuo formari, ſed latentes tantummodo in conſpectum producuntur augmento molis ex effluente ſucco.’ Id. ibid.

[d] From theſe, and other like conſiderations of the teeth, Galen infers, that they muſt needs be the work of ſome wiſe provident being, not chance nor a fortuitous concourſe of atoms. For the confirmation of which he puts the caſe, that ſuppoſe the order of the teeth ſhould have been inverted, the grinders ſet in the room of the inciſors, &c. (which might as well have been, had not the teeth been placed by a wiſe agent) in this caſe, what uſe would the teeth have been of? What confuſion by

and fartheſt from the centre, as being only preparers to the reſt; the others being to grind and mince, are accordingly made ſtronger, and placed nearer the centre of motion and ſtrength. Likewiſe their various forms [e], in various animals, is conſiderable, being all curiouſly adapted to the peculiar food [f], and all occaſions of the ſeveral

---

by ſuch a ſlight error in their diſpoſal only? Upon which he argues, 'At ſi quis choream hominum 32 (the number of the 'teeth) ordine diſpoſuit, eum ut hominem induſtrium laudare-'mus: cum vero dentium choream natura tam belle exornarit 'nonne ipſam quoque laudabimus?' And then he goes on with the argument, from the ſockets of the teeth, and their nice fitting in them, which being no leſs accurately done, than what is done by a carpenter, or ſtone-cutter, in fitting a tenon into a mortice, doth as well infer the art and act of the wiſe maker of animal bodies, as the other doth the act and art of man. And ſo he goes on with other arguments to the ſame effects. Galen, de Uſu Part. l. 11. c. 8.

[e] A curious account of this may be found in an Extract of a Letter concerning the teeth of diverſe animals. Printed at Paris, in M. Vougneon's complete body of chirurg. oper. c. 53.

[f] As it hath been taken notice of, that various animals delight in various food; ſo it conſtantly falls out, that their teeth are accordingly fitted to their food; the rapacious to catching, holding, and tearing their prey; the herbacious to gathering and comminution of vegetables: and ſuch as have no teeth, as birds,

ſeveral ſpecies of animals [f]. And laſtly, temporary defect of them [h], is no leſs obſervable in children, and ſuch young creatures, where there is no occaſion for them; but they would be rather an annoyance to the tender nipples and breaſts.

From the teeth, the grand inſtruments of maſtication, let us proceed to the other miniſterial

---

their bill, craw, and gizard, are aſſiſted with ſtones, to ſupply the defect of teeth. But the moſt conſiderable example of this kind is in ſome families of the inſect-tribes, as the papilio kind, &c. who have teeth, and are voracious, and live on tender vegetables in their nympha, or caterpillar ſtate, when they can only creep; but in their mature papilio ſtate, they have no teeth, but a proboſcis, or trunk, to ſuck up honey, &c. their parts for gathering food, as well as their food, being changed as ſoon as they have wings, to enable them to fly to it.

[g] It is remarkable in the teeth of fiſhes, that in ſome they are ſharp, as alſo jointed, ſo as to fall back, the better to catch and hold their prey, and to facilitate its paſſage into the ſtomach: ſo in others they are broad and flat, made to break the ſhells of ſnails and ſhell-fiſh devoured by them. Theſe teeth or breakers, are placed, in ſome in the mouth; in ſome in the throat; and in lobſters, &c. in the ſtomach itſelf; in the bottom of whoſe ſtomachs are three of theſe grinders, with peculiar muſcles to move them.

[h] What is there in the world can be called an act of providence and deſign, if this temporary defect of teeth be not ſuch? that children, for inſtance, ſhould have none whilſt they are not able

al parts. And here the parotid, ſublingual, and maxillary glands, together with thoſe of the cheeks and lips, are conſiderable; all lodged in the moſt convenient places about the mouth and throat, to afford that noble digeſtive ſalival liquor, to be mixed with the food in maſtication, and to moiſten and lubricate the paſſage, to give an eaſy deſcent to the food. The commodious form alſo of the jaws deſerves our notice; together with the ſtrong articulation of the lowermoſt and its motion. And laſtly, the curious form, the great ſtrength, the convenient lodgement and ſituation of the ſeveral muſcles and tendons [1], all miniſtering to this ſo neceſſary an act of life, as maſtication is; they are ſuch contrivances, ſuch works, as plainly ſet forth the infinite workman's care and ſkill.

---

able to uſe them, but to hurt themſelves, or the mother; and that at the very age when they can take in more ſubſtantial food, and live without the breaſt, and begin to need teeth, for the ſake of ſpeech; that then, I ſay, their teeth ſhould begin to appear, and gradually grow, as they more and more ſtand in need of them.

[1] It would be endleſs to particularize here, and therefore I ſhall refer to the anatomiſts; among the reſt, particularly to Galen, for the ſake of his deſcant upon this ſubject. For having deſcribed the great accuracy of the contrivance and make of theſe parts, he ſaith, 'Haud ſcio an hominum ſit ſobriorum ad

Next to the mouth, the gullet preſenteth itſelf; in every creature well-ſized to the food it hath occaſion to ſwallow; in ſome but narrow; in others as large and extenſive[k]: in all exceedingly remarkable for the curious mechaniſm of its muſcles, and the artificial decuſſation and poſition of their fibres[l].

And

'fortunam opificem id revocare: alioqui quid tandem erat, quod 'cum providentia atque arte efficitur? Omnino enim hoc ei con'trarium eſſe debet, quod caſu ac fortuito fit.' Galen, de Uſu Part. l. 11. c. 7. ubi plura.

[k] 'The bore of the gullet is not in all creatures alike an'ſwerable to the body or ſtomach. As in the fox, which both 'feeds on bones, and ſwallows whole, or with little chewing; 'and next in a dog, and other oſſivorous quadrupeds, 'tis very 'large, viz. to prevent a contuſion therein. Next in a horſe 'which though he feeds on graſs, yet ſwallows much at once, 'and ſo requires a more open paſſage. But in a ſheep, rabbit, 'or ox, which bite ſhort, and ſwallow leſs at once, it's ſmaller 'And in a ſquirrel, ſtill leſſer, both becauſe he eats fine, and to 'keep him from diſgorging his meat upon his deſcending leaps. 'And ſo in rats and mice, which often run along walls, with 'their heads downwards.' Dr. Grew's Comp. An. of Stom. and Guts. chap, 5.

[l] Of this ſee Dr. Willis's Pharm. Rat. Part. 1. ſect. 1. c. 3. Steno alſo, and Peyer. Mery. l. 2.

And now we are arrived to the grand receptacle of the food, the ſtomach; for the moſt part as various as the food to be conveyed therein. And here I might deſcribe the admirable mechaniſm of its tunics, muſcles, glands, the nerves, arteries, and veins [l]; all manifeſting the ſuper-eminent contrivance and art of the infinite workman [m]; they being all nicely adjuſted to their reſpective place, occaſion, and ſervice. I might alſo inſiſt upon that moſt neceſſary office of digeſtion; and here conſider that wonderful faculty of the ſtomachs of all creatures,

---

The deſcription theſe give of the muſcular part of the gullet the late ingenious and learned Dr. Drake ſaith is very exact in ruminants, but not in men. ' In men, this coat (the ſecond ' of the gullet) conſiſts of two fleſhy lamellæ, like two diſtinct ' muſcles. The outward being compoſed of ſtrait longitudinal ' fibres.——The inner order of fibres is annular, without any ' obſervable angles.—The uſe of this coat and theſe orders of ' fibres, is to promote deglutition; of which the longitudinal, ' ſhorten the œſophagus, and ſo make its capacity larger, to ad' mit of the matter to be ſwallowed. The annular, on the contra' ry, contract the capacity, and cloſing behind the deſcending ' aliment, preſs it downwards.' Drake's Anat. vol. I. 1. c. 9

[m] See Willis. ibid. Cowper's Anat. tab, 35, and many other authors.

[n] ' Promptuarium autem hoc, alimentum univerſum excipiens, ceu divinum, non humanum ſit opificium.' Galen de Uſu Part. l. 4. c. 1.

to diſſolve [o] all the ſeveral ſorts of food appropriated to their ſpecies; even ſometimes things of that conſiſtency as ſeem inſoluble [p]; eſpecially by ſuch ſeemingly ſimple and weak menſtruums as we find in their ſtomachs: but I ſhall only give theſe things a bare mention, and take more particular notice of the ſpecial proviſion made in the particular ſpecies of animals, for the digeſtion of that ſpecial food appointed them.

And in the firſt place it is obſervable, that, in every ſpecies of animals, the ſtrength
and

---

[o] 'How great a comprehenſion of the nature of thing did 'it require, to make a menſtruum, that ſhould corrode all ſorts 'of fleſh coming into the ſtomach, and yet not the ſtomach it'ſelf, which is alſo fleſh!' Dr. Grew's Coſmol. Sac. c. 4.

[p] The food of the caſtor being oftentimes, if not always, dry things, and hard of digeſtion, ſuch as the roots and bark of trees, it is a wonderful proviſion made in that creature's ſtomach, by the digeſtive juice lodged in the curious little cells there. A deſcription of whoſe admirable ſtructure and order may be found in Blaſius from Wepfer: concerning which he ſaith, 'In quibus mucus reconditus, non ſecus ac mel in favis—Nimi'rum quia Caſtoris alimentum exſuccum et, coctu difficillimum 'eſt ſapientiſſimus et ſumme admirandus in operibus rerum 'conditor, D. O M. ipſi pulcherrima iſta et affabre facta ſtructura 'benigniſſime proſpexit ut nunquam deeſſet fermentum, quod 'ad ſolvendum, et comminuendum alimentum durum et aſpe-
'rum

and ſize of their ſtomach [q] is conformable to to their food. Such whoſe food is more delicate tender, and nutritive, have commonly this part thinner, weaker and leſs bulky; whereas ſuch whoſe aliment is leſs nutritive, or whoſe bodies require larger ſupplies to anſwer their bulk, their labours, and waſte of ſtrength and ſpirits, in them it is large and ſtrong.

Another very remarkable thing in this part is the number of ventricles in diverſe creatures. In

---

'rum par foret.' Vide Blaſ. Anat. Animal. c. 10. Confer etiam Act. Erud. Lipſ. Ann. 1614. p. 360.

Moſt of our modern anatomiſts and phyſicians attribute digeſtion to a diſſolving menſtruum; but Dr. Drake takes it to be rather from fermentative, diſſolving principles in the aliment itſelf, with the concurrence of the air and heat of the body; as in Dr. Papin's Digeſter. Vide Dr. Anat. vol. 1. c. 14.

[q] 'All carnivorous quadrupeds have the ſmalleſt ventricles 'fleſh going fartheſt. Thoſe that feed on fruits, and roots, have 'them of a middle ſize. Yet the mole, becauſe it feeds uncleanly 'hath a very great one. Sheep and oxen, which feed on graſs, 'have the greateſt. Yet the horſe (and for the ſame reaſon the 'coney and hare) though graminivorous, yet comparatively have 'but little ones. For that a horſe is made for labour, and both 'this, and the hare, for quick and continued motion; for which the

In many but one; in ſome two or more [p]. In ſuch as make a ſufficient comminution of the food in the mouth, one ſuffices. But where teeth are wanting, and the food dry and hard, as in granivorous birds, there the defect is abundantly ſupplied by one thin membranaceous ventricle, to receive and moiſten the food, and another thick, ſtrong, muſcular one, to grind and tear it [s]. But in ſuch birds, and other creatures, whoſe food is not grain, but fleſh, fruits, inſects, or partly one, partly the other, there their ſtomachs

---

'the moſt eaſy reſpiration, and ſo the freeſt motion of the diaphragm, is very requiſite; which yet could not be, ſhould the ſtomach lie big and cumberſome upon it, as in ſheep and oxen it doth.' Grew, ibid. chap. 6

[p] The dromedary hath four ſtomachs one whereof is peculiarly endowed with about twenty cavities, like ſacks in all probability for the holding of water. Concerning which ſee book vi. chap. 4.

[s] To aſſiſt in which office, they ſwallow ſmall angular ſtones, which are to be met with in the gizards of all granivorous birds; but in the gizard of the iynx, or wry-neck, which was full only of ants, I found not one ſtone. So in that of the green wood-pecker, full of ants and tree-maggots, there were but few ſtones.

are accordingly conformable to their food [a], ſtronger or weaker, membranaceous or muſcular.

But as remarkable a thing as any in this part of animals, is the curious contrivance and fabric of the ſeveral ventricles of ruminating creatures. The very act itſelf of rumination is an excellent proviſion for the complete maſtication of the food, at the reſting, leiſure times of the animal. But the apparatus for this ſervice, of diverſe ventricles for its various uſes and purpoſes, together with their curious mechaniſm, deſerves great admiration [b].

Having thus far purſued the food to the place, where, by its reduction into chyle, it becomes a proper aliment for the body; I might next trace it through the ſeveral mæanders of the guts, the lacteals, and ſo into the blood [*], and afterwards into the very habit of the body: I might alſo take notice of the ſeparation made in the inteſtines, of what is nutritive, which is received, and what is feculent, being ejected, and the impregnations there from the pancreas and the gall; and after it hath been ſtrained through

---

[a] ‘In moſt carnivorous birds, the third ventricle is membraneous; where the meat is concocted, as in a man: or ſomewhat tendinous, as in an owl; as if it were made indifferently for fleſh, or other meat, as he could meet with either: or moſt thick and tendinous, called the gizard; wherein the meat as on a mill, is ground to pieces.’ Grew, ubi ſupra, c. 9.

[b] It would be much too long a taſk to inſiſt upon it here as it deſerves, and therefore concerning the whole buſineſs of rumination, I ſhall refer to J. Conr. Peyeri Merycolog. ſeu de Ruminantibus et Ruminatione commentar. Where he largely treateth of the ſeveral ruminating animals, of the parts miniſtering to this act, and the great uſe and benefit thereof unto them.

---

[*] There are too many particulars to be inſiſted on, obſervable in the paſſages of the chyle, from the guts to the left ſubclavian vein, where it enters into the blood; and therefore I ſhall only, for a ſample of this admirable œconomy, take notice of ſome of the main and more general matters. And.

1. After the food is become chyle, and gotten into the guts, it is an excellent proviſion made, not only for its paſſage through the guts, but alſo for its protruſion into the lacteals, by the periſtaltic motion, and valvulæ conniventes of the guts. 2. It is an admirable proviſion, that the mouths of the lacteals, and indeed the lacteals primi generis themſelves, are ſmall and fine, not wider than the capillary arteries are, leſt by admitting particles of the nouriſhment groſſer than the capillaries, dangerous obſtructions might be thereby produced. 3. After the reception of the aliment into the lacteals primi generis, it is a noble proviſion for the advancement of its motion, that in the meſenteric glands, it meets with ſome of the lymphæ-ducts, and receives the impregnation of the lympha. And paſſing on from thence, it is no leſs an advantage. 4. That the lacteals, and lymphæ-ducts meet in the receptaculum chyli, where the aliment meeting with more of the lympha, is made of a due conſiſtence and temperament, for its farther advancement through the

through thoſe curious colanders, the lacteal veins, I might alſo obſerve its impregnations from the glands and lymphæducts; and, to name no more I might farther view the exquiſite ſtructure of the parts miniſtering to all theſe delicate offices of nature; particularly the artificial conformation of the inteſtines might deſerve a ſpecial enquiry, their tunics, glands, fibres traverſing one another [x], and periſtaltic motion in all creatures; and their cochleous paſſage [y] to retard the motion of

---

the thoracic duct, and ſo into the left ſubclavian vein and blood. Laſtly, This thoracic duct itſelf is a part of great conſideration. For, as Mr. Cowper ſaith, ‘ If we conſider in this duct its ſeveral ‘ diviſions and inoſculations, its numerous valves looking from ‘ below upwards, its advantageous ſituation between the great ‘ artery and vertebræ of the back, together with the ducts diſ‑ ‘ charging their refluent lympha from the lungs, and other neigh‑ ‘ bouring parts, we ſhall find all conduce to demonſtrate the ut‑ ‘ moſt art of nature uſed in furthering the ſteep and perpendicu‑ ‘ lar aſcent of the chyle.’ Anat. Introduct.

[x] Theſe, although noble contrivances and works of God, are too many to be inſiſted on, and therefore I ſhall refer to the anatomiſts, particularly, Dr. Willis Pharmaceut, Dr. Cole in Phil. Tranſ. N° 125. and Mr. Cowper's elegant cuts in Anat. tab. 34. 35. And Append. fig. 39, 40.

[y] In the thornback, and ſome other fiſhes, it is a very curious proviſion, that is made to ſupply the paucity and brevity of the guts; by the perforation of their ſingle gut, going out ſtrait along, but round like a pair of winding-ſtairs, ſo that their gut, which ſeems to be but a few inches long, hath really a bore

of the chyle, and to make amends for the ſhortneſs of the inteſtines. in ſuch creatures who have but one gut; together with many other accommodations of nature in particular animals that might be mentioned. But it ſhall ſuffice to have given only a general hint of thoſe curious and admirable works of God. From whence it is abundantly manifeſt, how little weight there is in the former atheiſtical objection. Which will receive a further confutation from the

VI. And laſt thing relating to food, that I ſhall ſpeak of, namely, ‘ the great ſagacity of ‘ all animals, in finding out and providing their food.’ In man, perhaps, we may not find any thing very admirable or remarkable in this kind, by means of his reaſon and underſtanding, and his ſupremacy over the inferior creatures; which anſwereth all his occaſions relating to this buſineſs: but then even here the Creator hath ſhewed his ſkill, in not over doing the matter; in not providing man with an unneceſſary apparatus, to effect over and over again what is feaſible, by the reach of his underſtanding, and the power of his authority.

---

a bore of many inches. But of theſe and many other noble curioſities and diſcoveries in anatomy, the reader will, I hope have a better and larger account from the curious and ingenious Dr. Dowglas, who is labouring in thoſe matters.

But for the inferior creatures, who want reaſon, the power of that natural inſtinct, that ſagacity [z] which the Creator hath imprinted upon them, doth amply compenſate that defect. And here we ſhall find a glorious ſcene of the divine wiſdom, power, providence, and care, if we view the various inſtincts of beaſts, great, and ſmall, of birds, inſects, and reptiles[a]. For among every ſpecies of them, we may find notable acts of ſagacity, or inſtinct, proportional to their occaſions for food. Even among thoſe whoſe food is near at hand, and eaſily come at; as graſs and herbs; and conſequently have no great need of art to diſcover it: yet, that faculty of their accurate ſmell and taſte, ſo ready at every turn, to diſtinguiſh between what is ſalutary, and what pernicious[b], doth juſtly deſerve praiſe. But for ſuch animals, whoſe food is not ſo eaſily come at, a variety of wonderful inſtincts may be met with, ſufficient to entertain the moſt curious obſerver. With what entertaining power and artifice do ſome creatures hunt[c], and purſue their game and

---

[z] 'Quibus beſtiis erat is cibus, ut alius generis beſtiis veſcerentur, aut vires natura dedit, aut celeritatem: data eſt quibuſdam etiam machinatio quædam, atque ſolertia, &c.' Cic. de Nat. Deor. l. 2. c. 48.

[a] Among reptiles that have a ſtrange faculty to ſhift for food, &c. may be reckoned eels, which although belonging to the waters, can creep on the land from pond to pond, &c. Mr. Moſely of Moſely, ſaw them creep over the meadows, like ſo many ſnakes from ditch to ditch; which he thought, was not only for bettering their habitation, but alſo to catch ſnails in the graſs. Plot's Hiſtory of Staffordſhire. c. 7. ſect. 32.

And as early as the year 1125, the froſt was ſo very intenſe that the eels were forced to leave the waters, and were frozen to death in the meadows. Vide Hakewill's Apol, l. 2. c. 7. ſect. 2.

[b] 'Enumerare poſſum, ad paſtum capeſſendum conficiendumque, quæ ſit in figuris animantium et quam ſolers, ſubtiliſque deſcriptio partium, quamque admirabilis fabrica membrorum. Omnia enim quæ intus incluſa ſunt, ita nata, atque ita locata ſunt, ut nihil eorum ſupervacaneum ſit, nihil ad vitam retinendam non neceſſarium. Dedit autem eadem natura belluis et ſenſum, et appetitum, ut altero conatum haberent ad naturales paſtus capeſſendos; altero ſecernerent peſtifera a ſalutaribus.' Cic. de Nat. Deor. l. 2. c. 37. See book. iv. c. 4.

[c] It would be endleſs to give inſtances of my own and others obſervations, of the prodigious ſagacity of diverſe animals in hunting, particularly hounds, ſetting-dogs, &c. one therefore ſhall ſuffice, of Mr. Boyle's, viz. 'A perſon of quality—to make a trial, whether a young blood hound was well inſtructed,——cauſed one of his ſervants—to walk to a town four miles off, and then to a market-town three miles from thence——The dog, without ſeeing the man he was to purſue, followed him by the ſcent to the above-mentioned places, notwithſtanding the multitude of market-people that went along in the ſame way, and of travellers that had occaſion to croſs it. And when the blood-hound came to the chief market town, he paſſed through the

and prey! And others watch and way-lay theirs [d]! With what prodigious ſagacity do others grope for it under ground, out of ſight in mooriſh places, in mud and dirt [e]; and others dig and delve

---

‘ the ſtreets, without taking notice of any of the people there, ‘ and left not off, till he had gone to the houſe, where the man he ‘ ſought reſted himſelf, and found him in an upper room, to the ‘ wonder of thoſe that followed him.’ Boyle deter. Nat. of Eff. ‘ c. 4.

[d] There are many ſtories told of the craft of the fox, to compaſs his prey: of which Ol. Magnus hath many, ſuch as feigning the barking of a dog, to catch prey near the houſes; feigning himſelf dead, to catch ſuch animals as come to feed upon him; laying his tail on a waſp-neſt, and then rubbing it hard againſt a tree, and then eating the waſps ſo killed: ridding himſelf of fleas, by gradually going into the water, with a lock of wool in his mouth, and ſo driving the fleas' up into it, and then leaving it in the water: by catching crab-fiſh with his tail, which, he ſaith, he himſelf was an eye-witneſs of: ‘ Vidi et ego ‘ in Scopulis Norvegiæ vulpem, inter rupes immiſſa cauda in aquas, plures educere cancros, demum devorare.’ Ol. Mag. Hiſt. l. 18. c. 39, 40.

But Pliny's fabulous ſtory of the hyæna out does theſe relations of the fox. ‘ Sermonem humanum inter paſtorum ſtabula ‘ aſſimulare, nomenque alicujus addiſcere, quem evocatum foras ‘ laceret. Item vomitionem hominis imitari ad ſollicitandos canes ‘ quos invadat.’ Plin. Nat. Hiſt. l. 8. c. 30.

[e] This do ducks, woodcocks, and many other fowls, which ſeek their food in dirty, mooriſh places. For which ſervice they have

delve for it, both above [f], and under the ſurface of the drier lands [g]? And how curious and well-deſigned a proviſion is it of particular large nerves in ſuch creatures, adapted to that eſpecial ſervice!

What an admirable faculty is that of many animals to diſcover their prey at vaſt diſtances; ſome by their ſmell ſome miles off [h]: and ſome by

---

have very remarkable nerves reaching to the end of their bills, Of which ſee book vii. chap. 2.

[f] Swine, and other animals that dig, have their noſes made more tendinous, callous, and ſtrong for this ſervice, than others that do not dig. They are alſo edged with a proper, tough border, for penetrating and lifting up the earth; and their noſtrils are placed well, and their ſmell is very accurate, to diſcover whatſoever they purſue by digging.

[g] The mole, as its habitation is different from that of other animals, ſo hath its organs in every reſpect curiouſly adapted to that way of life; particularly its noſe made ſharp, and ſlender, but withal tendinous and ſtrong, &c. But what is very remarkable, it hath ſuch nerves reaching to the end of its noſe and lips, as ducks, &c. Which pair of nerves I obſerved to be much larger in this animal than any other nerves proceeding out of its brain.

[h] Predacious creatures, as wolfs, foxes, &c. will diſcover prey at great diſtances; ſo will dogs and ravens diſcover carrion a great way off by their ſmell. And if, as the ſuperſtitious imagine, the latter flying over and haunting houſes be a ſign of death

by their ſharp and piercing ſight, aloft in the air, or at other great diſtances[i]! An inſtance of the latter of which God himſelf giveth, (Job xxxix. 27, 28, 29.) in the inſtinct of the eagle: 'Doth the eagle mount up at thy command, and make her neſt on high? She dwelleth and abideth, on the rock, upon the crag of the rock and the ſtrong place[k]. From thence ſhe ſeeketh

---

death, it is no doubt from ſome cadaverous ſmell thoſe ravens diſcover in the air by their accurate ſmell, which is emitted from thoſe diſeaſed bodies, which have in them the principles of a ſpeedy death.

[i] Thus hawks and kites on land, and gulls, and other birds, that prey upon the waters, can, at a great height in the air, ſee mice, little birds and inſects on the earth, and ſmall fiſhes, ſhrimps, &c. in the waters, which they will dart down upon, and take.

[k] Mr. Ray gives a good account of the nidification of the chryſætos, cauda annulo albo cincta. 'Hujus nidus anno 1668. in ſylvoſis prope Derwentiam, &c. inventus eſt e bacillis ſeu virgis ligneis grandioribus compoſitus quorum altera extremitas rupis cujuſdam eminentiæ altera duabas betulis innitebatur,—erat nidus quadratus, duas ulnas latus.——In eo pullus unicus, adjacentibus cadaveribus unius agni, unius leporis, et trium grygallorum pullorum.' Synopſ. Method. Avium, p. 6. And not only lambs, hares, and grygalli, but Sir Robert Sibbald tells us, they will ſeize kids and fawns; yea, and children too: of which he hath this ſtory of an eagle in one of the Orcades iſlands: 'Quæ infantulum unius anni pannis involutum arripuit (quem mater teſſellas uſtibiles pro igne allatura momento temporis depoſuerat in loco Houton-head dicto) eumque deportaſſe

‘ ſeeketh her prey, and her eyes, behold afar off.’ What a commodious proviſion hath the contriver of nature made for animals, that are neceſſitated to climb for their food; not only in the ſtructure of their legs and feet, and in the ſtrength of their tendons and muſcles, acting in that particular office [l] ; but alſo in the peculiar ſtructure of the principal parts, acting in the acqueſt of their food [m] ! What a proviſion alſo is that in nocturnal birds

---

‘ per 4 milliaria paſſuum ad Hoiam; qua re ex matris ejulatibus ‘ cognita, quatuor viri illuc in navicula profecti ſunt, et ſcien‘ tes ubi nidus eſſet, infantulum illæſum et intactum deprehen‘ derunt.’ Prod. Nat. Hiſt. Scot. l. 3. part. 2. p. 14.

[l] See in book vii. chap. 1. the characteriſtics of the woodpecker-kind.

[m] ‘ The contrivance of the legs, feet, and nails [of the ‘ opoſſum] ſeems very advantageous to this animal in climbing ‘ trees, which it doth very nimbly, for preying upon birds. But that which is moſt ſingular in this animal, is the ſtructure of its tail, to enable it to hang on boughs. ‘ The ſpines, or ‘ hooks——in the middle of the under ſide of the vertebrae of the ‘ tail, are a wonderful piece of natute’s mechaniſm. The firſt ‘ three vertebræ had none of theſe ſpines, but in all the reſt ‘ they were to be obſerved.——They were placed juſt at the articu‘ lation of each joint, and in the middle from the ſides.——For the ‘ performing this office [of hanging by the tail] nothing, I think ‘ could be more advantageouſly contrived. For when the tail is ‘ twirled or wound about a ſtick, this hook of the ſpinæ eaſily ‘ ſuſtains the weight, and there is but little labour of the muſcles

birds and beaſts, in the peculiar ſtructure of their eye, (and we may perhaps add the accuracy of their ſmell too) whereby they are enabled to diſcover their food in the dark! But among all the inſtances we have of natural inſtinct, thoſe inſtincts, and eſpecial proviſions, made to ſupply the neceſſities of helpleſs animals, do, in a particular manner, demonſtrate the great Creator's care. Of which I ſhall give two inſtances.

1. The proviſion made for young creatures. That Στοργὴ that natural affection, ſo connatural to all, or moſt creatures towards their young [n],

---

'cles required, only enough for bowing or crooking the tail.' This, and more to the ſame purpoſe, ſee in Dr. Tyſon's Anatomy of the Opoſſum, in Phil. Tranſ. N° 239.

[n] 'Quid dicam quantus amor beſtiarum ſit in educandis cuſ'todiendiſque iis, quas procreaverint uſque ad eum finem, dum 'poſſint ſeipſas defendere!' And having inſtanced in ſome animals, where this care is not neceſſary, and accordingly is not employed, he goes on, 'Jam gallinæ, aveſque reliquæ, et quietum 'requirunt ad pariendum locum, et cubilia ſibi, nidoſque con'ſtruunt, eoſque quam poſſunt molliſſime ſubſternunt, ut quam 'facillime ova ſerventur. Ex quibus pullos cum excluſerint, ita 'tuentur, ut et pennis foveant, ne frigore lædantur, et ſi eſt ca'lor a ſole ſe opponant.' Cic. de Nat. Deor. l. 2. c. 51, 52.

To this natural care of parent animals to their young, we may add the returns made by the young of ſome towards the what an admirable noble principle is it, implanted in them by the wiſe Creator! By means of which, with what alacrity do they tranſact their parental miniſtry! With what care do they nurſe up their young; think no pains too great to be taken for them, no dangers [o] too great to be ventured

---

old ones. Pliny ſaith of rats, 'Genitores ſuos feſſos ſenecta, alunt 'inſigni pietate.' Nat. Hiſt. l. 8. c. 57. So cranes, he ſaith, 'Genitricum ſenectam invicem educant.' Libr 18. c. 23.

This St. Ambroſe takes notice of in his Hexameron, and Ol. Magnus, after him, 'Depoſiti patris artus, per longævam ſe'nectutem plumis nudatos circumſtans ſoboles pennis propriis fo'vet,——collatitio cibo paſcit, quando etiam ipſa naturæ reparat 'diſpendia, ut hinc inde ſenem ſublevantes, fulcro alarum ſuarum 'ad volandum exercent, et in priſtinos uſus deſueta membra 'reducant.' For which reaſon this bird is denominated Pia. Vide Ol. Mag. Hiſt. l. 19. c. 14.

Hereto may be added alſo the conjugal Στοργὴ of the little green Æthiopian parrot, which Mr. Ray deſcribes from Cluſrus. 'Foemellæ ſeneſcentes, quod valde notabile, vix edere volebant, 'niſi cibum jam a mare carptum, et aliquandiu in prolobo re'tentum, et quaſi coctum roſtro ſuo exciperent, ut columbarum 'pulli a matre ali ſolent.' Synopſ. Meth. Av. p 32.

[o] The moſt timid animals, that at other times abſcond, or haſtily fly from the face of man, dogs, &c. will, for the ſake of their young, expoſe themſelves. Thus among fowls, hens will aſſault, inſtead of fly from ſuch as meddle with their brood. So partridges, before their young can fly, will drop frequently down, firſt at leſſer, and then at greater diſtances, to dodge and draw off dogs from purſuing their young.

upon for their guard and ſecurity! How carefully will they lead them about in places of ſafety, carry them into places of retreat and ſecurity; yea ſome of them admit them into their own bowels p! How will they careſs them with their affectionate notes, lull, and quiet them with their tender parental voice, put food into their mouths ſuckle them, them, cheriſh and keep them warm, teach them to pick, and eat, and gather food for themſelves, and, in a word, perform the whole part of ſo many nurſes, deputed by the ſovereign Lord and preſerver of the world, to help ſuch young and ſhiftleſs creatures, till they are come to that maturity, as to be able to ſhift for themſelves!

And as for other animals (particularly inſects, whoſe fire is partly the ſun, and whoſe numerous offspring would be too great for their parent-

---

p The opoſſum hath a curious bag on purpoſe for the ſecuring and carrying about her young. There are belonging to this bag two bones, not to be met with in any other ſkeleton, and four pair of muſcles; and ſome ſay the teats lie therein alſo. Dr. Tyſon. Anat. of the Opoſſ. in Phil. Tranſ. N° 239. where he alſo, from Oppian, mentions the dog-fiſh, that upon any ſtorm or danger, receives the young ones into her belly, which come out again when the fright is over. So alſo the ſquatina and glaucus, the ſame author ſaith, have the ſame care for their young, but receive them into different receptacles.

animals care and proviſion) theſe are ſo generated as to need none of their care, by reaſon they arrive immediately to their Ἡλικία, their perfect, adult ſtate, and are able to ſhift for themſelves. But yet, thus far their parental inſtinct (equivalent to the moſt rational care and foreſight doth extend, that the old ones do not wildly drop their eggs and ſperm any where, at all adventures, but ſo cautiouſly repoſit it in ſuch commodious places (ſome in the waters, ſome on fleſh, ſome on plants, proper and agreeable to their ſpecies [q]; and ſome ſhut up agreeable food in their neſts, partly for incubation, partly for food [r], that their young, in their aurelia or nympha ſtate, may find ſufficient and agreeable food to bring them up, till they arrive to their maturity.

Thus far the parental inſtinct and care.

Next we may obſerve no leſs in the young themſelves, eſpecially in thoſe of the irrational animals. Foraſmuch as the parent-animal is not able to bear them about, to clothe them, and to dandle them, as man doth; how admirably hath the Creator contrived their ſtate, that thoſe poor young creatures can ſoon walk about, and with the little helps of their dam, ſhift for, and help themſelves! how naturally do they hunt for their teat, ſuck, pick [s], and take in their proper food!

---

[q] See book viii. chap. 6.

[r] See chap. 13.

But for the young of man, their parents reaſon joined with natural affection, being ſufficient to help to nurſe, to feed, and to clothe them; therefore they are born helpleſs, and are more abſolutely, than other creatures, caſt upon their parents care [t]. A manifeſt act and deſignation of the divine providence!

---

[s] There is manifeſtly a ſuperintending providence in this caſe, that ſome animals are able to ſuck as ſoon as ever they are born, and that they will naturally hunt for the teat before they are quite got out of the ſecundines, and parted from the navel-ſtring, as I have ſeen. But for chickens, and other young birds, they not being able immediately to pick till they are ſtronger, have a notable proviſion made for ſuch a time, by a part of the yolk of the egg being incloſed in their belly, a little before their excluſion or hatching, which ſerves for their nouriſhment, till they are grown ſtrong enough to pick up meat. Vide book vii. chap. 4.

[t] 'Qui [infantes] de ope noſtra ac de divina miſericordia plus 'merentur, qui in primo ſtatim nativitatis ſuæ ortu plorantes ac 'flentes, nil aliud faciunt quam deprecantur,' Cypr. Ep. ad Fid.

2. The other inſtance I promiſed, is the proviſion made for the preſervation of ſuch animals as are ſometimes deſtitute of food, or in danger of being ſo. The winter is a very inconvenient, improper ſeaſon, to afford either food or exerciſe to inſects, and many other animals. When the flowery fields are diveſted of their gaiety; when the fertile trees and plants are ſtripped of their fruits, and the air, inſtead of being warmed with the cheriſhing beams of the ſun, is chilled with rigid froſt; what would become of ſuch animals as are impatient of cold! what food could be found by ſuch as are ſubſiſted by the ſummer-fruits ? But to obviate all this evil, to ſtave off the deſtruction and extirpation of diverse ſpecies of animals, the infinitely wiſe preſerver of the world hath as wiſely ordered the matter; that in the firſt place, ſuch as are impatient of cold, ſhould have ſuch a ſpecial ſtructure of their body, particularly of their hearts, and circulation of their blood [u], as during that ſeaſon, not to ſuffer any waſte of their body, and conſequently not to

---

[u] I might mention here ſome of the ſpecies of birds, the whole tribe almoſt of inſects, and ſome among other tribes, that are able to ſubſiſt for many months without food, and ſome without reſpiration too, or very little: but it may ſuffice to inſtance only in the land tortoiſe; of the ſtructure of whoſe heart and lungs, ſee book vi. chap. 5.

need any recruits; but that they ſhould be able to live in a kind of ſleepy, middle ſtate, in their places of ſafe retreat, until the warm ſun revives both them and their food together.

The next proviſion is for ſuch as can bear the cold, but would want food then; and that is in ſome by a long patience of hunger [x], in others by their notable inſtinct in laying up food before-hand againſt the approaching winter. Of this many entertaining examples may be given; particularly we may, at the proper ſeaſon, obſerve not only the little treaſures and holes well-ſtocked with timely proviſions, but large fields [z] here and there

---

[x] 'Inediam diutſſime tolerat lupus, ut et alia omnia carnivora, licet voraciſſima; magna utique naturæ providentia; quoniam eſca non ſemper in promptu eſt.' Rap's Syn. Quadr. p. 174.

To the long abſtinence mentioned of brute animals, I hope the reader will excuſe me, if I add one or two inſtances of extraordinary abſtinence among mankind. One Martha Taylor born in Derbyſhire, by a blow on the back fell into ſuch a proſtration of appetite, that ſhe took little ſuſtenance, but ſome drops with a feather, from Chriſtmas 1667, for thirteen months and ſlept but little too all the time. See Dr. Thompſon's account thereof, in Ephem. Germ. T. 3. obſ. 173.

To this we may add the caſe of S. Chilton, of Tinſbury, near Bath, who, in the years 1693, 1696, and 97, ſlept divers weeks together. And although he would ſometimes, in a very odd manner, take ſuſtenance, yet would lie a long time without any, or with very little, and all without any conſiderable decay. See Phil. Tranſ. N° 304.

---

[y] They are admirable inſtincts which the Sieur de Beauplau relates of his own knowledge of the little animals called bohaques in Ukraine 'They make burroughs like rabbits, and in 'October ſhut themſelves up, and do not come out again till 'April.——They ſpend all the winter under ground, eating what 'they laid up in ſummer.——Thoſe that are lazy among them 'they lay on their backs, then lay a great handful of dry herbage upon their bodies &c. then others drag thoſe drones to 'the mouths of their burroughs, and ſo thoſe creatures ſerve inſtead of barrows, &c. I have often ſeen then practiſe this, 'and have had the curioſity to obſerve them whole days together.——Their holes are parted like chambers; ſome ſerve for 'ſtore-houſes, others for burying-places, &c: Their government is nothing inferior to that of bees, &c. They never 'go abroad without poſting a centinel upon ſome high ground, 'to give notice to the others whilſt they are feeding. As ſoon as 'the centinel ſees any body, it ſtands upon its hind-legs and 'whiſtles.' Beauplau's Deſcription of Ukraine, in vol. I. of the collection of voyages, &c.

A like inſtance of the northern galli ſylveſtres ſee in chap. 13.

As for the ſcriptural inſtance of the ant, ſee hereafter book viii. chap. 5.

I have in autumn, not without pleaſure obſerved, not only the great ſagacity and diligence of ſwine, in hunting out the ſtores of there throughhout beſpread with conſiderable numbers of the fruits of the neighbouring trres, laid carefully up in the earth, and covered ſafe, by the provident little animals inhabiting thereabouts. And not without pleaſure; have I ſeen and admired the ſagacity of other animals, hunting out thoſe ſubterraneous fruits, and pillaging the treaſures of thoſe little provident creatures.

And now, from this bare tranſient view of this branch of the great Creator's providence and government, relating to the food of his creatures, we can conclude no leſs, than that ſince this grand affair hath ſuch manifeſt ſtrokes of admirable and wiſe management, that ſince this is demonſtrated throughout all ages and places, that therefore it is God's handy-work. For, how is it poſſible that ſo vaſt a world of animals ſhould be ſupported, ſuch a great variety equally and well

---

of the field mice; but the wonderful precaution alſo of thoſe little animals, in hiding their food before-hand againſt winter. In the time of acorns falling, I have, by means of the hogs, diſcovered, that the mice had, all over the neighbouring fields, treaſured up ſingle acorns in little holes they had ſcratched, and in which they had carefully covered up the acorns. Theſe the hogs would, day after day, hunt out by their ſmell.

ſupplied with proper food, in every place fit for habitation, without an eſpecial ſuperintendency and management, equal to, at leaſt, that of the moſt prudent ſteward and houſholder! How ſhould the creatures be able to find out their food when laid up in ſecret places? And how ſhould they be able to gather even a great deal of the common food, and at laſt to macerate and digeſt it, without peculiar organs adapted to the ſervice? And what leſs than an infinitely wiſe God could form ſuch a ſet of curious organs, as we find every ſpecies endowed with for this very uſe? Organs ſo artificially made, ſo exquiſitely fitted up, that the more ſtrictly we ſurvey them, the more accurately we view them, even the meaneſt of them with our beſt glaſſes, the leſs fault we find in them, and the more we admire them; whereas the beſt poliſhed, and moſt exquiſite works, made by human art, appear through our glaſſes, as rude and bungling, deformed and monſtrous; and yet we admire them, and call them works of art and reaſon. And laſtly, what leſs than rational and wiſe, could endow irrational animals with various inſtincts, equivalent in their ſpecial way, to reaſon itſelf? Inſomuch that ſome from thence have abſolutely concluded that thoſe creatures had ſome glimmerings of reaſon. But it is manifeſtly inſtinct, not reaſon they act by, becauſe we find no varying, but that every ſpecies doth naturally purſue at all times the ſame methods and way without any tutorage or learning: whereas reaſon without inſtruction, would often vary, and do that by many methods, which inſtinct doth by one alone. But of this more hereafter.

CHAP. XII.

OF THE CLOTHING OF ANIMALS.

HAVING, in the foregoing chapter, ſomewhat largely taken a view of the infinite Creator's wiſdom and goodneſs towards his creatures, in ordering their food, I ſhall be more brief in this chapter in my view of their clothing [a]; another neceſſary appendage of life, and in which we have plain tokens of the Creator's art manifeſted in theſe two particulars; the ſuitableneſs of animals clothing to their place and occaſions; and the garniture and beauty thereof.

I. The clothing of animals is ſuited to their place of abode, and occaſions there: a manifeſt act of deſign and ſkill. For, if there was a poſſibility, that animals could have been accoutred any other way, than by God that made them it muſt needs have come to paſs that their clothing would have been at all adventures, or all made the ſame mode and way, or ſome of it, at leaſt, inconvenient and unſuitable. But, on the contrary, we find all is curious and complete, nothing too much, nothing too little, nothing bungling, nothing but what will bear the ſcrutiny of the moſt exquiſite artiſt; yea, and ſo far out-do his beſt ſkill, that his moſt exquiſite imitations, even of the meaneſt hair, feather, ſcale, or ſhell, will be found only as ſo many ugly ill-made blunders and botches, when ſtrictly brought to the teſt of good glaſſes. But we ſhall find an example remarkable enough in the preſent caſe, if we only compare the beſt of clothing which man makes for himſelf, with that given by the Creator for the covering of the irrational creatures, of which it may be ſaid, as our Saviour doth of the flowers of the field, Mat. vi. 29. ‘ That even Solomon in all his glory, was not arrayed like one of theſe.’

---

[a] Concerning the clothing of animals, Ariſtotle obſerves, 'That ſuch animals have hair as go on feet, and are viviparous; 'and that ſuch are covered with a ſhell, as go on feet, and are 'oviparous.' Hiſt. Anim. l. 3 c. 10.

But let us come to particulars, and conſider the ſuitableneſs of the different method the Creator hath taken in the clothing of man, and of the irrational

tional animals. This Pliny [b] pathetically laments, and ſays, ‘ It is hard to judge, whether ‘ nature hath been a kinder parent, or more ‘ cruel ſtep-mother to man. For, ſays he, of ‘ all creatures he alone is covered with others ‘ riches; whereas nature hath given various ‘ clothing to other animals, ſhells, hides, prick‘ les, ſhag briſtles, hair, down, quills ſcales, ‘ fleeces; and trees ſhe hath fenced with a ‘ bark or two againſt the injuries of cold and ‘ heat. Only poor naked man, ſays he, is in

---

[b] ‘ Cujus [hominis] cauſa videtur cuncta alia genuiſſe natu‘ ra, magna et ſæva mercede contra tanta ſua munera: ut non ‘ ſit ſatis æſtimare, parens melior homini, an triſtior noverca ‘ fuerit. Ante omnia unum animantium cunctorum alienis velat ‘ opibus: cæteris varia tegumenta tribuit, teſtas cortices, coria, ‘ ſpinas, villos, ſetas, pilos, plumam, pennas, ſquamas, vellera. ‘ Truncos etiam arboreſque cortice, interdum gemino, a frigori‘ bus, et calore tutata eſt. Hominem tantum nudum, et in nu‘ da humo, natali die abjicit ad vagitus ſtatim et ploratum, nul‘ lumque tot animalium aliud ad lacrymas, et has protinus vitæ ‘ principio.’ Plin. Nat. Hiſt. l. 7. Proem.

Let Seneca anſwer this complaint of Pliny, although perhaps what he ſaith might be more properly noted in another place: ‘ Quiſquis es iniquus æſtimator ſortis humanæ, cogita quanta no‘ bis tribuerit parens noſter, quanto valentiora animalia ſub jugum ‘ miſerrimus, quanto velociora aſſequamur, quam nihil ſit mortale ‘ non ſub ictu noſtro poſitum. Tot virtutes accepimus, tot artes ‘ animum denique cui nihil non eodem quo intendit momento ‘ pervium eſt, ſideribus velociorem,’ &c. Sen. de Ben. l. 2. 29.

‘ the day of his birth caſt into the wide world, ‘ to immediate crying and ſqualling : and none ‘ of all creatures beſides, ſo ſoon to tears in the ‘ very beginning of their life.’

But here we have a manifeſt demonſtration of the care and wiſdom of God towards his creatures ; that ſuch ſhould come into the world with their bodies ready furniſhed and accommodated, who had neither reaſon nor forecaſt to contrive, nor parts adapted to the artifices and workmanſhip of clothing ; but for man, he being endowed with the tranſcending faculty of reaſon, and thereby made able to help himſelf, by having thoughts to contrive, and withal hands to effect, and ſufficient materials [c] afforded him from the ſkins and fleeces of animals and from various trees and plants: man, I ſay, having

---

[c] ‘ Mirantur plurimi quomodo tute, et ſane vivant homines in horrendis frigoribus plagæ ſeptentrionalis ; hancque levem quæſtionem ultra 30 annos audieram in Italia, præſertim ab Æthiopibus, et Indis, quibus oneroſus videtur veſtitus ſub zona torrida.——Quibus reſpondetur,—gaudet Indus multiplici plumarum genare, magis forſan pro tegumento, quam neceſſitate : rurſus Scytha villoſo veſtitu.——Ita ſub polo arctico adverſus aſperrimas hyemes—opportuna remedia faciliter adminiſtrat [natura,] ligna videlicet in maxima copia, et leviſſimo pretio, et demum pelles diverſorum, animalium tam ſylveſtrium quam domeſticorum.’ Then he gives a catalogue of them, and faith, ‘ Quorum omnium experti pellifices ita ingenioſe noverunt mixturas componere, ut pulcherrimum decorem oſtendat vari-

'varietas, et callidiſſimum fomentum adjuncta mollities.' Ol. Mag. Hiſt. l. 6. c. 20.

To this guard againſt the cold, namely, of fire and clothing, I hope the reader will excuſe me, if I take this opportunity of adding ſome other defenſatives, nature, or rather the great author of nature, hath afforded theſe northern regions: ſuch are their high mountains, abounding, as Ol. Magnus ſaith, through all parts: alſo their numerous woods, which, beſides their fire, do, with the mountains, ſerve as excellent ſcreens againſt the cold piercing air, and winds. Their prodigious quantities of minerals, and metals, alſo afford heat, and warm vapours. 'Mineræ ſeptentrionalium regionum ſatis multæ, magnæ, diverſæ, et opulentæ ſunt,' ſaith the ſame curious, and, for his time, learned archbiſhop, l. 6. c. 1, and in other places. And for the warmth they afford, the volcanos of thoſe parts are an evidence; as are alſo their terrible thunder and lightning, which are obſerved to be the moſt ſevere and miſchievous in their metalline mountains, in which large herds of cattle are ſometimes deſtroyed; the rocks ſo rent and ſhattered, that new veins of ſilver are thereby diſcovered; and a troubleſome kind of quinſy is produced in their throats, by the ſtench, and poiſonous nature of the ſulphureous vapours, which they diſſolve, by drinking warm beer and butter together, as Olaus tells us in the ſame book, chap. 11.

To all which defenſatives I ſhall in the laſt place add, the warm vapours of their lakes, (ſome of which are prodigiouſly large, of 130 Italian miles in length, and not much leſs in breadth;) alſo of their rivers, eſpecially the vapours which ariſe from the ſea. Of which guard againſt ſevere cold, we have lately had having all this proviſion made for him, therefore the Creator hath wiſely made him naked, and left him to ſhift for himſelf, being ſo well able to help himſelf.

And a notable act this is of the wiſdom of God not only as the mere ſetting forth his care and kindneſs to them that moſt needed his help, the helpleſs irrational animals, and in his not over doing his work; but alſo as it is moſt

---

had a convincing proof in the great froſt, in 1708, wherein, when England, Germany, France, Denmark, yea, the more ſoutherly regions of Italy, Switzerland, and other parts, ſuffered ſeverely, Scotland and Ireland felt very little of it, hardly more then in other winters; of the particulars of which, having given an account in the Phil. Tranſ. N° 324. I ſhall thither refer the reader. But, it ſeems, this is what doth ordinarily befal thoſe northern parts; particularly the iſlands of Orkney, of which the learned Dr. Wallace gives this account: ‘ Here the winters are ‘ generally more ſubject to rain than ſnow; nor doth the froſt ‘ and ſnow continue ſo long here as in other parts of Scotland; ‘ but the wind in the mean time will often blow very boiſterouſly; ‘ and it rains ſometimes, not by drops, but by ſpouts of water, ‘ as if whole clouds fell down at once. In the year 1680, in the ‘ month of June, after great thunder, there fell flakes of ice ‘ near a foot thick.’ Wall. Account of Orkney, chap. 1. p. 4. From which laſt paſſage I obſerve, that although in thoſe parts, the atmoſphere near the earth be warm, it is exceſſively cold above, ſo as to freeze ſome of thoſe ſpouts of water in their deſcent, into ſuch great, and almoſt incredible, maſſes of hail. And whence can this warmth proceed, but from the earth, or ſea, emitting heat ſufficient to ſtave off the cold above? Conſult book ii. chap. 5.

agreeable to the nature and ſtate of man [d], both on natural and political accounts. That man ſhould clothe himſelf, is moſt agreeable to his nature, particularly, among other things, as being moſt ſalutary, and moſt ſuitable to his affairs. For, by this means, man can adapt his clothing to all ſeaſons, to all climates, to this, or to any buſineſs. He can hereby keep himſelf ſweet and clean, fence off many injuries; but above all, by this method of clothing, with the natural texture of his ſkin adapted to it, it is that the grand means of health, namely, inſenſible perſpiration [e], is performed, at leaſt greatly promoted without which an human body would be ſoon over-run with diſeaſes.

---

[d] 'Sicut enim ſi innata ſibi [i. e. homini] aliqua haberet 'arma, illa ei ſola ſemper adeſſent, ita et ſi artem aliquam na'tura ſortitus eſſent, reliquas ſane non haberet. Quia vero ei 'melius erat omnibus armis omnibuſque artibus uti, neutrum eo'rum a natura ipſi propterea datum eſt.' Gal. de uſu Part. l. '1. c. 4.

[e] Concerning inſenſible perſpiration, Sanctorius obſerves, that it much exceeds all the ſenſible put together. De Stat. Med. Aph. 4. That as much is evacuated by inſenſible perſpiration in one day, as is by ſtool in fourteen days: particularly, that, in a night's time, about ſixteen ounces is commonly ſent out by urine, four ounces by ſtool; but above forty ounces by inſenſible perſpiration. Aphor. 59, 60. That if a man eats and drinks eight pounds in a day, five pounds of it is ſpent in inſenſible perſpiration. Sect. 1 Aph. 6. And as to the times, he

In the next place, there are good political reaſons for man's clothing himſelf; inaſmuch as his induſtry is hereby employed in the exerciſes of his art and ingenuity; his diligence and care are exerted in keeping himſelf ſweet, cleanly, and neat; many callings and ways of life ariſe from thence, and, to name no more, the ranks and degrees of men are hereby, in ſome meaſure, rendered viſible to others, in the ſeveral nations of the earth.

Thus it is manifeſtly beſt for man, that he ſhould clothe himſelf.

But for the poor ſhiftleſs irrationals, it is a prodigious act of the great Creator's indulgence that they are all ready furniſhed with ſuch clothing, as is proper to their place and buſi-

---

he ſaith, 'Ab aſſumpto cibo 5 horis ℔ circiter perſpirabilis—'exhalare ſolet; 5a ad 12am 3 ℔ circiter; a 12a ad 16am vix ſelibram.' Aph. 56.

And as to the wonderful benefits of inſenſible perſpiration, they are abundantly demonſtrated by the ſame learned perſon, ubi ſupra; as alſo by Borelli in his ſecond part, de Mor. Animal. prop. 168. who ſaith, 'Neceſſaria eſt inſenſibilis tranſpiratio, 'ut vita animalis conſervetur.'

neſs[f]. Some covered with hair[g], ſome with feathers

---

[f] ‘ Animantium vero quanta varietas eſt! Quanta ad eam rem vis, ut in ſuo quæque genere permaneant! Quarum ali coriis tectæ ſunt, aliæ villis veſtitæ, aliæ ſpinis hirſutæ pluma alias, alias ſquama videmus obductas, alias eſſe cornibus armatas, alias habere effugia pennarum,’ Cic. de Nat. Deor. l. 2. c. 47.

[g] From Malpighi’s curious obſervations of the hair, I ſhall note three things: 1: Their ſtructure is fiſtulous, or tubular; which hath long been a doubt among the curious. ‘ Fiſtuloſum [eſſe pilum] demonſtrat pilorum luſtratio a cauda et collo equorum, &c.——præcipue ſetarum apri, quæ patentiorem ex fiſtulis compoſitionem exhibent. Eſt autem dictus apri pilus cylindricum corpus quaſi diaphanum fiſtularum aggere conflatum, et ſpeciem columnæ ſtriatæ præ ſe fert, Componentes fiſtulæ in gyrum ſituatæ in apice patentiores redduntur; nam hians pilus ingeminas dividitur partes, et componentes minimæ fiſtulæ——liberiores redditæ manifeſtantur, ita ut enumerari poſſint: has autem 20, et ultra numeravi.—Expoſitæ fiſtulæ——tubuloſæ ſunt, et frequentibus tunicis tranſverſaliter ſituatis, veluti valvulis pollent. Et quoniam ſpinæ, in erinaceis præcipue, &c. nil aliud ſunt, quam duri et rigidi pili, ideo,’ &c. And then he deſcribes the hedge-hog’s ſpines, in which thoſe tubes manifeſtly appear; together with medullary valves and cells; not inelegant, which he hath figured in tab. 16. at the end of his works.

That which this ſagacious, and not enough to be commended obſerver, took notice of in the ſtructure of hair, and its parity to the ſpines, I have myſelf obſerved in ſome meaſure to be true, in the hair of cats, rats, mice and diverſe other animals; which look very prettily when viewed with a good microſcope. The hair of a mouſe, the moſt tranſparent of any I have viewed, ſeems to be one ſingle tranſparent tube, with a pith made up of a fibrous ſubthers [h], ſome with ſcales, ſome with ſhells [i] ſome only ſkin, and ſome with firm and ſtout armature: all nicely accommodated to the element in which the creature liveth, and its occaſions there [k]. To quadrupeds hair is a commodious

---

ſubſtance, running in dark lines; in ſome hairs tranſverſly, in others ſpirally, as in Fig. 14. 15, 16, 17. Theſe darker medullary parts, or lines, I have obſerved, are no other than ſmall fibres convolved round, and lying cloſer together than in other parts of the hair. They run from the bottom to the top of the hair; and, I imagine, ſerve to the gentle evacuation of ſome humour out of the body; perhaps, the hair ſerves as well for the inſenſible perſpiration of hairy animals, as to fence againſt cold and wet. In Fig. 14, 16. is repreſented the hair of a mouſe, as it appears through a ſmall magnifier: and in Fig. 15, 17. as it appears when viewed with a larger magnifier.

Upon another review, I imagine, that although in Fig. 14. 15. the dark parts of the pith ſeem to be tranſverſe, that they, as well as in the two other figures, run round in a ſcrew-like faſhion.

[h] See book vii. chap. 1.

[i] See chap. 14.

[k] It is a ſign ſome wiſe artiſt was a contriver of the clothing of animals, not only as their clothing varies, as their way of living doth; but alſo becauſe every part of their bodies is furniſhed with proper ſuitable clothing. Thus diverſe animals, that have their bodies covered for the moſt part with ſhort, ſmooth hair, ſome have parts left naked, where hair would be an annoyance; and ſome parts beſet with long hair, as the mane

modious clothing; which, together with the apt texture of their ſkin, fitteth them for all weathers to lie on the ground, and to do the offices of man; and the thick and warm furs and fleeces of others are not only a good defenſative againſt the cold and wet; but alſo a ſoft bed to repoſe themſelves in; and to many of them a comfortable covering, to nurſe and cheriſh their tender young.

And as hair to quadrupeds, ſo feathers are as commodious a dreſs to ſuch as fly in the air to birds, and ſome inſects; not only a good guard againſt wet and cold, and a comfortable covering to ſuch as hatch and brood their young but alſo moſt commodious for their flight. To which purpoſe they are nicely and neatly placed every where on the body, to give them an eaſy paſſage through the air [1] and to aſſiſt in the

---

and tail; and ſome with ſtiff, ſtrong briſtles, as about the noſe; and ſometimes within the noſtrils, to guard off, or give warning of annoyances.

[1] The feathers being placed from the head towards the tail, in cloſe and neat order, and withal preened and dreſſed by the contents of the oil-bag, afford as eaſy a paſſage through the air, as a boat new cleaned and dreſſed finds in its paſſage through the waters. Whereas, were the feathers placed the contrary, or any other way, (as they would have been, had they been placed by

the wafting their body through that thin medium. For which ſervice, how curious is their texture for lightneſs, and withal for ſtrength! Hollow and thin for lightneſs, but withal, context and firm for ſtrength. And where it is neceſſary they ſhould be filled, what a light and ſtrong medullary ſubſtance is it they are filled with! By which curious contrivances, even the very heavieſt parts made for ſtrength, are ſo far from being a load to the body that they rather aſſiſt in making it light and buoyant, and capacitate it for flight. But for the vanes, the lighteſt part of the feather, how curiouſly are they wrought with capillary filaments, neatly interwoven together [m], whereby they are not only light, but alſo ſufficiently cloſe and ſtrong, to keep the body warm, and guard it againſt the injuries of weather, and withal, to impower the wings like ſo many ſails to make ſtrong impulſes upon the air in their flight [n]. Thus curious, thus artificial, thus

---

by chance, or without art) they would then have gathered air, and been a great incumbrance to the paſſage of the body through the air. See book vii. chap. 1.

[m] In book vii. chap. 1. there is a particular account of the mechaniſm of their vanes, from ſome nice microſcopical obſervations, and therefore I ſhall take no farther notice of it here.

[n] Vide Borell. de Mot. Animal Prop. 181. vol. 1.

commodious is the clothing of beaſts and birds! concerning which, more in its proper place.

And no leſs might I ſhew that of reptiles and fiſhes [o] to be, if it was convenient to enlarge upon this branch of the Creator's work. How well adapted are the annuli of ſome reptiles, and the contortions of the ſkin of others, not only to fence the body ſufficiently againſt outward injuries, but to enable them to creep, to perforate the earth [p]! and, in a word, to perform all the offices of their reptile ſtate, much better than any other tegument of the body would do! And the ſame might be ſaid of the covering of the inhabitants of the waters, particularly the ſhells of ſome which are a ſtrong guard to the tender body that is within, and conſiſtent enough with their ſlower motion; and the ſcales and ſkins of others, affording them an eaſy and ſwift paſſage through the waters. But it may be ſufficient to give only a hint of theſe things, which more properly belong to another place.

---

[o] See book ix.

[p] For a ſample of this branch of my ſurvey, let us chuſe the teguments of earth worms, which we ſhall find completely adapted to their way of life and motion, being made in the moſt complete manner poſſible for terebrating the earth, and creeping where their occaſions lead them: for their body is made throughout of ſmall rings and theſe rings have a curious apparatus of muſcles enabling thoſe creatures with great ſtrength to dilate, extend, or contract their annuli, and whole body; thoſe annuli alſo are each of them armed with ſmall, ſtiff, ſharp beards, or prickles, which they can open, to lay hold on, or ſhut up cloſe to their body: and laſtly, under the ſkin there lies a ſlimy juice that they emit, as occaſion is, at certain perforations between the annuli, to lubricate the body, and facilitate their paſſage into the earth. By all which means they are enabled, with great ſpeed, eaſe, and ſafety, to thruſt and wedge themſelves into the earth; which they could not do, had their bodies been covered with

Thus hath the indulgent Creator furniſhed the whole animal world with convenient, ſuitable clothing.

II. Let us, in the next place, take a ſhort view of the garniture [q], and beauty thereof. And here we ſhall thus far, at leaſt, deſcry it to be beautiful; that it is complete and workman-like. Even the clothing of the moſt ſordid animals, thoſe that are the leaſt beautified with colours, or

---

with hair, feathers, ſcales, or ſuch like clothing of the other creatures. See more concerning this animal, book ix. chap. 1.

[q] Ariſtotle, in his Hiſt. Anim. l. 3. c. 12. names ſeveral rivers, that by being drank of, change the colour of the hair.

rather whoſe clothing may regrate the eye [r]; yet when we come ſtrictly to view them, and ſeriouſly conſider the nice mechaniſm of one part, the admirable texture of another, and the exact ſymmetry of the whole; we diſcern ſuch ſtrokes of inimitable ſkill, ſuch incomparable curioſity, that we may ſay with Solomon, Eccl. iii. '[God] 'hath made every thing beautiful in his time.'

But for a farther demonſtration of the ſupereminent dexterity of his almighty hand, he hath been pleaſed, as it were on purpoſe, to give ſurprizing beauties to divers kinds of animals. What radiant colour are many of them, particularly ſome birds and inſects [s], bedecked with!

---

[r] For an example, let us take the clothing of the tortoiſe and viper: becauſe, by an incurious view, it rather regrateth; than pleaſeth the eye: but yet by an accurate ſurvey we find the ſhells of the former, and the ſcales of the latter, to be a curious piece of mechaniſm, neatly made, and ſo completely, and well put and tacked together, as to exceed any human compoſures: of the latter, ſee more in book ix. chap. 1.

[s] It would be endleſs to enter into the particulars of the beautiful brids and inſects of our European parts; and eſpecially thoſe inhabiting the countries between the tropics, which are obſerved as much to exceed our birds in their colours, as ours do theirs in their ſinging.

What a prodigious combination is there often of thoſe, yea, how nice an air frequently of meaner colours [t], as to captivate the eye of all beholders, and exceed the dexterity of the moſt exquiſite pencil to copy!

And now, when we thus find a whole world of animals, clothed in the wiſeſt manner, the moſt ſuitable to the element in which they live, the place in which they reſide, and their ſtate and occaſions there; when thoſe that are able to ſhift for themſelves, are left to their own diſcretion and diligence, but the helpleſs, well accoutered and provided for; when ſuch incomparable ſtrokes of art and workmanſhip appear in all, and ſuch inimitable glories and beauties in the clothing of others; who can, with the greateſt obſtinacy and prejudice, deny this to be God's handy-work? The gaudy, or even the meaneſt apparel, which man provideth for himſelf, we readily enough own to be the contrivance, the work of man: and ſhall we deny the clothing of all the animal world beſides, which infinitely ſurpaſſeth all the robes of earthly majeſty; ſhall we, dare we deny, that to be the work of any thing leſs than of an infinite, intelligent Being, whoſe art and power are equal to ſuch glorious work!

---

[t] The wryneck, at a diſtance, is a bird of mean colour; neither are indeed its colours radiant, or beautiful, ſingly conſidered: but when it is in the hand, we ſee its light and darker colours ſo curiouſly mixed together, as to give the bird a ſurprizing beauty. The ſame is alſo obſervable in many inſects, particularly of the phalæna kind.

CHAP. XIII.

OF THE HOUSES AND HABITATION OF ANIMALS.

HAVING, in the laſt chapter, as briefly as I well could, ſurveyed the clothing of animals, I ſhall in this take a view of their houſes, neſts, their cells and habitations, another thing no leſs neceſſary to their well-being than the laſt; and in which the great Creator hath likewiſe ſignalized his care and ſkill, by giving animals an architectonic faculty, to build themſelves convenient places of retirement, in which to repoſe and ſecure themſelves, and to nurſe up their young.

And here, as before, we may conſider the caſe of man, and that of the irrational animals. Man having, as I ſaid, the gift of reaſon and underſtanding, is able to ſhift for himſelf, to contrive and build, as his pleaſure leads him, and his abilities will admit of. From the meaneſt huts and cottages, he can erect himſelf ſtately buildings, bedeck them with exquiſite arts of architecture, painting, and other garniture; ennoble them, and render them delightful with pleaſant gardens, fountains, avenues, and what not? For man therefore the Creator hath abundantly provided in this reſpect, by giving him an ability to help himſelf. And a wiſe proviſion this is, inaſmuch as it is an excellent exerciſe of the wit, the ingenuity, the induſtry, and care of man.

But ſince ingenuity, without materials, would be fruitleſs, the materials therefore which the Creator hath provided the world with, for this very ſervice of building, deſerve our notice. The great varieties of trees [u], earth, ſtones, and plants, anſwering every occaſion and purpoſe of man for this uſe, in all ages and places all the world over, is a great act of the Creator's goodneſs; as manifeſting, that ſince he has left man to ſhift for himſelf, it ſhould not be without ſufficient helps to enable him to do ſo, if he would but make uſe of them, and the ſenſe and reaſon which God hath given him.

---

[u] ————Dant utile lignum
Navigiis pinos, domibus cedroſque, cupreſſoſque;
Hinc radios trivere rotis, hinc tympana plauſtris
Agricolæ, et pandas ratibus poſuere carinas
Viminibus ſalices foecundæ, frondibus ulmi;
At myrtus validis haſtilibus, et bona bello
Cornus; Ityræos taxi torquentur in arcus.
Nec tiliæ leves, aut torno raſile buxum,
Non formam accipiunt, ferroque cavantur acuto:
Necnon et torrentem undam levis innatat alnus
Miſſa Pado: necnon et apes examina condunt
Corticibuſqus cavis, vitioſæque illicis alveo.
Virg. Georg. I. 2. carm. 442.

Thus ſufficient proviſion is made for the habitation of man.

And no leſs, ſhall we find, is made for the reſt of the creatures; who, although they want the power of reaſon to vary their methods, and cannot add to, or diminiſh from, or any way make improvements upon their natural way, yet we find that natural inſtinct, which the Creator's infinite underſtanding hath imprinted in them, to be abundantly ſufficient, nay in all probability, the very beſt or only method they can take, or that can be invented, for the reſpective uſe and purpoſe of each peculiar ſpecies of animals[x]. If ſome creatures make their neſts in houſes, ſome in trees, ſome in ſhrubs, ſome in the earth [y]; ſome in ſtone, ſome in the waters, ſome here, and ſome there, or havenone at all; yet we find, that that place, that method of nidification, doth abundantly anſwer the creatures uſe and occaſions. They can there ſufficiently and well repoſe, and ſecure themſelves, lay, and breed up their young. We are ſo far from diſcovering any inconvenience in any of their reſpective ways, from perceiving any loſs befal the ſpecies, any decay, any periſhing of their young; that in all probability, on the contrary in that particular way, they thrive better, are more ſecure, and better able to ſhift for, and help themſelves. If, for inſtance ſome beaſts make to themſelves no habitation, but lie abroad in the open air, and there produce their young; in this caſe we find there is no need it ſhould be otherwiſe, by reaſon they are either taken care of by man[z], or in no danger, as other creatures, from abroad. If others repoſite their young in holes * and dens, and ſecure themſelves alſo therein, it is becauſe ſuch guard, ſuch ſecurity, is wanting, their lives being ſought either by the hoſtility of man, or to ſatisfy the appetite of rapacious creatures. If among birds, ſome build their neſts cloſe, ſome open, ſome with this ſome with another material, ſome in houſes, ſome in trees, ſome on the ground [a] ſome on rocks and crags on high, (of which God himſelf hath given an inſtance in the eagle, Job xxxix, 27, 28.) And ſo among the inſect and reptile kinds, if ſome repoſite their eggs or young in the earth, ſome in wood, ſome in ſtone, ſome on one kind of plant, ſome on another, ſome in warm and dry places, ſome in the water, and moiſt places, and ſome in their

---

[x] See chap. 15. and book xiii, chap. 6

---

[y] Many of the veſpæ ichneumones are remarkable enough for their nidification and proviſion for their young. Thoſe that build in earth (which commonly have golden and black rings round their alvi) having lined the little cells they have perforated, lay therein their eggs, and then carry into them maggots from he leaves of trees, and ſeal them up cloſe and neatly. And another ichneumon, more of the veſpa than muſca-ichneumon kind, (having a little ſting in its tail, of a black colour) gave me the pleaſure, one ſummer, of ſeeing it build its neſt in a little hole in my ſtudy-window. This cell was coated about with an odoriferous, reſinous gum, collected, I ſuppoſe, from ſome fir-trees near: after which it laid two eggs, I think the number was, and then carried in divers maggots, ſome bigger then itſelf. Theſe it very ſagaciouſly ſealed cloſe up into the neſt, leaving them there, doubtleſs, partly to aſſiſt the incubation; and eſpecially for food to the future young, when hatched.

Of this artifice of theſe ichneumons, Ariſtotle himſelf takes notice, (but I believe he was Scarce aware of the eggs ſealed up with the ſpiders.) ʻΟι δε Σφῆκες Ιχνεύμονες καλȣ̀μενοι, &c. ‘ As ‘ to the veſpæ, called ichneumones, leſs than others they kill ‘ ſpiders, and carry them into their holes, and having ſealed ‘ them up with dirt, they therein hatch, and produce thoſe of ‘ the ſame kind.’ Hiſ. Anim. l. 5, c. 20

To what hath been ſaid abou theſe ichneumon waſps, I ſhall add one obſervation more, concerning the providential ſtructure of their mouth in every of their tribes, viz. their jaws are not only very ſtrong, but nicely ſized, curved, and placed for gnawing and ſcraping thoſe complete little holes they perforate in earth, wood, yea, in ſtone itſelf.

---

[z] Tully having ſpoken of the care of ſome animals towards their young, by which they are nurſed and brought up ſaith, 'Accidit etiam, ad nonnullorum animantium, et earum, 'rerum quas terra gignit, conſervationem, et ſalutem, hominum 'etiam ſolertia et diligentia. Nam multæ et pecudes, et ſtirpes 'ſunt, quæ ſine procuratione hominum ſalvæ eſſe non poſſunt. Cic, de. Nat. Deor. l. 2. c. 52.

* Prov. xxx. 26. 'The conies are but a feeble folk, yet 'make they their houſes in the rocks.'

---

[a] It is a notable inſtinct which Ol. Magnus tells of the galli ſylveſtres, in his northern country, to ſecure themſelves againſt the cold and ſtorms of the winter. 'Cum nives inſtar collium terræ ſuperficiem ubique cooperiunt, ramoſque arborum diutius deprimunt et condenſant, certos fructus betulæ arboris ——in forma longi piperis vorant, et glutiunt indigeſtos; idque tanta aviditate, ac quantitate ut repletum guttur toto corpore majus appareat. Deinde partitis agminibus ſeſe inter medios nivium colles immergunt, præſertim, in Jan. Febr. Martio, quando nives ut turbines, typhones, vel tempeſtates graviſſimæ e nubibus deſcendunt. Cumque coopertæ ſunt——certis hebdomadis cibo in guttures collecto, egeſto, et reſumpto vivunt, venatorum canibus non produntur.——Quod ſi præſentiunt nivem imminere majorem, prædicto fructu iterum devorato, aliud domicilium captant, in eoque manent uſque ad finem Martii,' &c. Ol. Mag. Hiſt. l. 19. c. 33.

own bodies only, as ſhall be ſhewn in proper place; in all theſe caſes it is, in all probability, the beſt or only method the animal can take for the hatching and production of its young, for their ſupplies, ſafety, or ſome other main point of their being or well-being. This is manifeſt enough in many caſes, and therefore probable in all. It is manifeſt that ſuch animals, for inſtance, as breed in the waters, (as not only fiſh, but divers inſects, and other land-animals do) that their young cannot be hatched, fed, or nurſed up in any other element. It is manifeſt alſo that inſects, which lay their eggs on this, and that and the other agreeabe tree, or plant, or in fleſh, &c. that it is by that means their young are fed and nurſed up. And it is little to be doubted alſo, but that theſe matrixes may much conduce to the maturation and production of the young. And ſo in all other the like caſes of nidification of heat or cold, wet or dry, expoſed or open in all probability this is the beſt method for the animal's good, moſt ſalutary and agreeable to its nature, moſt for its fecundity, and the continuance and increaſe of its ſpecies; to which every ſpecies of animals is naturally prompt and inclined.

Thus admirable is the natural ſagacity and inſtinct [b] of the irrational animals in the convenience and method of their habitations And no leſs is it in the fabric of them. Their architectonic ſkill, exerted in the curioſity and dexterity of their works, and exceeding the ſkill of man to imitate; this, I ſay, deſerves as much or more admiration and praiſe, than that of the moſt exquiſite artiſt among men. For with what inimitable art * do theſe poor untaught creatures lay a parcel of rude and ugly ſticks and ſtraws, moſs and dirt together, and form them into commodious neſts! With what curioſity do they line them within, wind and place every hair, feather, or lock of wool, to guard the tender bodies of themſelves, and their young, and to keep them warm! And with what art and craft do many of them thatch over and coat their neſts without, to dodge and deceive the eye of ſpectators, as well as to guard and fence againſt the injuries of weather [c]! With what prodigious ſubtilty do ſome foreign birds [d] not only plat and weave the fibrous parts of vegetables together, and curiouſly tunnel them and commodiouſly form them into neſts, but alſo artificially ſuſpend them on the tender twig of trees, to keep them out of the reach of rapacious animals!

---

[b] It is a very odd ſtory (which I rather mention for the reader's diverſion, than for its truth) which Dr. Lud. de Beaufort relates. 'Vir fide dignus narravit mihi, quod cum ſemel, 'animi gratia, nidum aviculæ ligno obturaſſet, ſeque occultaſſet, 'cupidus videndi, quid in tali occaſione præſtaret; illa cum fruſtra ſæpius tentaſſet roſtro illud auferre, caſus admodum im'patiens abiit, et poſt aliquod temporis ſpatium reverſa eſt, ro'ſtro gerens plantulam, qua obturamento applicata, paulo poſt, illud veluti telum eripuit tanta vi, ut diſperſa impetu herbula, 'occaſionem ipſi, ab avicula ejus virtutem diſcendi, præripuerit. Coſmog. Divina. ſect. 5. cap. 1. Had he told us what the plant was, we might have given better credit to this ſtory.

* Of the ſubtilty of birds in nidification ſee Plin. Nat. Hiſt. l. 10. c. 33.

---

[c] Among many inſtances that might be given of this ſubtilty of birds and other creatures, that of the long tailed titmouſe deſerves obſervation, who, with great art, builds her neſt with moſſes, hair, and the webs of ſpiders, caſt out from them when they take their flight: ſee book viii; chap. 4, with which the other materials are ſtrongly tied together. Having neatly built, and covered her neſt with theſe materials without, ſhe thatcheth it on the top with the ‘ muſcus arboreus ramoſus,’ or ſuch like broad, whitiſh moſs, to keep out rain, and to dodge the ſpectator's eye; and within ſhe lineth it with a great number of ſoft feathers, ſo many, that I confeſs I could not but admire how ſo ſmall a room could hold them, eſpecially that they could be laid ſo cloſe and handſomely together, to afford ſufficient room for a bird with ſo long a tail, and ſo numerous an iſſue as this bird commonly hath, which Mr. Ray ſaith (Synopſ. Method. Avium, p. 74.) ‘ Ova inter omnes aviculas numeroſiſſima ponit.’ See more of the neſt of this bird, from Aldrovand. in Willough. Ornith. p. 243.

[d] The neſt of the guira tangeima, the icterus minor, and the jupujuba, or whatever other name the American hang-neſts may be called by, are of this kind. Of which ſee Willoughby's Ornith. lib. 2. cap. 5. ſect. 12, 13. Alſo Dr. Grew's Muſæum Reg

And ſo for inſects, thoſe little weak, thoſe tender creatures; yet, what admirable artiſts are they in this buſineſs of nidification! With what great diligence doth the little bee gather its combs from various trees[e] and flowers, the waſp from ſolid timber[f]. And with what prodigious

---

Reg. Reg. Soc. part 1. ſect. 4. cap. 4. Theſe neſts I have divers times ſeen, particularly in great perfection in our R. S. repoſitory, and in the noble and well-furniſhed Muſæum of my often commended friend, Sir Hans Sloane; and at the ſame time I could not but admire at the neat mechaniſm of them, and the ſagacity of the bird, in hanging them on the twigs of trees, to ſecure their eggs and young from the apes.

[e] I mention trees, becauſe I have ſeen bees gather the gum of fir-trees, which at the ſame time gave me the pleaſure of ſeeing their way of loading their thighs therewith, performed with great art and dexterity.

[f] Waſps, at their firſt coming, may be obſerved to frequent poſts, boards, and other wood that is dry and ſound; but never any that is rotten. Theſe they may be heard to ſcrape and gnaw; and what they ſo gnaw off, they heap cloſe together between their chin and fore-legs, until they have gotten enough for a burden, which they then carry away in their mouths, and make their cells with.

digious geometrical ſubtilty do thoſe little animals work their deep hexagonal cells, the only proper figure that the beſt mathematician could chuſe for ſuch a combination of houſes[h] ! With what accuracy do other inſects perforate the earth[i], wood, yea, ſtone itſelf[k] ! For which ſervice, the complete apparatus of their mouths[l], and feet[m], deſerves particular obſervation, as hath been, and will be hereafter obſerved. And further yet; with what care and neatneſs do moſt of thoſe little ſagacious animals line thoſe their houſes within, and ſeal them up, and fence them without [m]. How artificially will others fold up the leaves of trees and plants, others houſe themſelves in ſticks and ſtraws; others

---

[h] Circular cells would have been the moſt capacious; but this would by no means have been a convenient figure, by reaſon much of the room would have been taken up by vacancies between the circles; therefore it was neceſſary to make uſe of ſome of the rectilinear figures: Among which only three could be of uſe; of which Pappus Alexandrinus thus diſcourſeth: 'Cum 'igitur tres figuræ ſunt, quæ per ſeipſas locum circa idem punc- 'tum conſiſtentem replere poſſunt, triangulum, ſcil. quadratum 'et hexagonum, apes illam, quæ ex pluribus angulis conſtat, ſa- 'pienter delegerunt, utpote ſuſpicantes eam plus mellis capere 'quan utramvis reliquarum. At apes quidem illud tantum quod 'ipſis utile eſt cognoſcunt, viz. hexagonum quadrato et triangulo 'eſſe majus, et plus mellis capere poſſe; nimirum æquali materia 'in conſtructionem uniuſcujuſque conſumpta. Nos vero qui plus 'ſapientiæ quam apes habere profitemur, aliquid etiam magis in- 'ſigne inveſtigabimus.' Collect. Math. l. 5.

[i] See before.

[k] See chap. 11.

[l] See chap. 11:

[m] Among many examples, the legs and feet of the mole-cricket (Gryllotalpa) are very remarkable. The fore-legs are very brawny and ſtrong; and the feet armed each with four flat

---

flat ſtrong claws, together with a ſmall lamina, with two larger claws, and a third with two little claws: which lamina is jointed to the bottom of the foot, to be extended, to make the foot wider, or withdraw within the foot. Theſe feet are placed to ſcratch ſomewhat ſideways, as well as downward, after the manner of moles feet; and they are very like them alſo in figure.

Somewhat of this nature, Swammerdam obſerves of the worms of the Ephemeron. 'To this purpoſe [to dig their cells] 'the wiſe Creator hath furniſhed them, ſaith he, with fit members. For, beſides that their two fore-legs are formed ſomewhat like thoſe of the ordinary moles, or gryllotalpa; he hath 'alſo furniſhed them with two toothy cheeks, ſomewhat like 'the ſheers of lobſters, which ſerve them more readily to bore 'the clay.' Swammerdam's Ephem. Vit. publiſhed by Dr. Tyſon, chap. 3.

[m] See the before-cited.

[n] They are for the moſt part, ſome of the phalænæ-tribe which inhabit the tunnelled, convolved leaves, that we meet with on vegetables in the ſpring and ſummer. And it is a ſomewhat wonderful artifice, how ſo ſmall and weak a creature, as one of theſe newly-hatched maggots (for doubtleſs it is they, not the animal, becauſe ſhe emits no web, nor hath any textrine art

others glue light and floating bodies together [*], and by that artifice make themſelves floating houſes in the waters, to tranſport themſelves at pleaſure after their food, or other ne-

---

art) can be able to convolve the ſtubborn leaf, and then bind it in that neat round form, with the thread or web it weaves from its own body; with which it commonly lines the convolved leaf, and ſtops up the two ends, to prevent its own falling out, and earwigs, and other noxious animals, getting in.

[*] The ſeveral ſorts of phryganea, or cadews in their nympha, or maggot-ſtate, thus houſe themſelves; one ſort in ſtraws, called from thence ſtraw-worms; others in two or more ſticks, laid parallel to one another, creeping at the bottom of brooks; others with a ſmall bundle of pieces of ruſhes, duck-weed ſticks, &c. glued together, therewith they float on the top, and can row themſelves therein about the waters with the help of their feet; both theſe are called cod-bait. Divers other ſorts there are, which the reader may ſee a ſummary of, from Mr. Willoughby, in Raii Method. Inſect. p. 12. together with a good, though very brief deſcription of the papillionaceous fly, that comes from the cod-bait cadew. It is a notable architectonic faculty, which all the variety of theſe animals have, to gather ſuch bodies as are fitteſt for their purpoſe, and then to glue them together; ſome to be heavier than water, that the animal may remain at the bottom, where its food is; (for which purpoſe they uſe ſtones, together with ſticks, ruſhes, &c.) and ſome to be lighter than water, to float on the top, and gather its food from thence. Theſe little houſes look coarſe, and ſhew no great artifice outwardly; but are well tunnelled, and made within with a hard tough paſte; into which the hinder part of the maggot is ſo fixed, that it can draw its cell after it any where, without danger of leaving it behind; as alſo thruſt its body out, to reach what it wanteth; or withdraw it into its cell to guard it againſt harms.

ceſſary occaſions of life! And for a cloſe, let us take the ſcriptural inſtance of the ſpider, Prov. xxx. 28. which is one of the four little things, which, ver. 24. Agur ſays, is exceeding wiſe: The ſpider taketh hold with her 'hands, and is in kings palaces [p].' I will not diſ-

---

[p] Having mentioned the ſpider, I ſhall take this occaſion, although it be out of the way, to give an inſtance of the poiſon of ſome of them. Scaliger, Exerc. 186. relates, 'That in 'Gaſcony, his country, there are ſpiders of that virulency, that 'if a man treads upon them, to cruſh them, their poiſon will 'paſs through the very ſoles of his ſhoe.' Boyl. Subtil. of Effluv. c. 4.

Mr. Leewenhoek put a frog and a ſpider together into a glaſs, and having made the ſpider ſting the frog divers times, the frog died in about an hour's time. Phil. Tranſ. N° 272.

In the ſame Tranſaction, is a curious account of the manner how ſpiders lay, and guard their eggs, viz. they emit them not out of the hindermoſt part of the body, but under the upper part of her belly, near the hind legs. &c. Alſo there is an account of the parts from which they emit their webs, and divers other things worth obſervation, with cuts illuſtrating the whole.

But in Phil. Tranſ. N° 22. Dr. Nath. Fairfax, from S. Redi, and his own obſervations, thinks ſpiders not venomous; ſeveral perſons, as well as birds, ſwallowing them without hurt: which I myſelf have known in a perſon of learning, who was adviſe to take hem medicinally at firſt, and would at any time ſwallow them, affirming them to be ſweet, and well-taſted: and not only innocuous, but they are very ſalutiferous too, in ſome of the moſt ſtubborn diſeaſes, if the pleaſant ſtory in Mouffet be true, of a rich London matron, cured of a deſperate tympany, diſpute the truth of our Engliſh tranſlation of this text! but ſuppoſing the animal mentioned to be that which is meant, it is manifeſt that the art of that ſpecies of creatures, in ſpinning their various webs, and the furniture their bodies afford to that purpoſe, are an excellent inſtinct and proviſion of nature, ſetting forth its glorious author.

And now, from this ſhort and tranſient view of the architectonic faculty of animals, eſpecially the irrationals, we may eaſily perceive ſome ſuperior and wiſe being was certainly concern-

---

pany, by a certain debauchee, that hearing of her caſe, and that ſhe was given over by the doctors, went to her, pretending to be a phyſician, and confidently affirming he would cure her; which ſhe being willing to believe, agrees with him for ſo much money, one half to be paid down, the other upon cure. Upon which he gives her a ſpider, promiſing her cure in three days. Whereupon (not doubting but that he had poiſoned her, and fearing he might be called to account for it) he gets out of town as faſt as he could. But inſtead of being poiſoned, ſhe ſoon recovered. After ſome months, the quack gets privately to town, when he thought the buſtle might be over; and enquiring how his patient did, was informed of her cure; and thereupon viſiting her, and making an excuſe for his abſence, he received his pay with great applauſe and thanks. Mouff. Inſect. l. 2. c. 15.

Having ſaid ſo much of ſpiders, I might here add their flight: but of this, ſee book viii. chap. 4.

ed in their creation or original. For, how is it poſſible that an irrational creature ſhould, with ordinary and coarſe, or indeed any materials, be ever able to perform ſuch works, as exceed even the imitation of a rational creature! How could the bodies of many of them, particularly the laſt mentioned, be furniſhed with architective materials! How could they ever diſcover them to be in their bodies, or know what uſe to make of them! We muſt therefore neceſſarily conclude, that the irrationals either have reaſon and judgment, not only glimmerings thereof, but ſome of its ſuperior acts, as wiſdom and foreſight, diſcretion, art, and care; or elſe that they are only paſſive in the caſe, and act by inſtinct, or by the reaſon of ſome ſuperior being imprinted in their nature, or ſome way or other, be it how it will, congenial with them. That they are rational, or excel man in art and wiſdom, none ſurely will be ſo fooliſh as to ſay: and therefore we muſt conclude, that thoſe excellent ends they purſue, and that admirable art they exert, is none of their own, but owing to that infinitely-wiſe and excellent being, of whom it may be ſaid, with reference to the irrational, as well as rational creatures, as it is, Prov. ii. 6. ‘ The Lord giveth wiſ‘ dom; out of his mouth cometh knowledge and ‘ underſtanding.’

CHAP.

CHAP. XIV.

OF ANIMALS SELF-PRESERVATION.

HAVING thus conſidered the food, clothing, and houſes of animals: let us in this chapter take a glance of another excellent proviſion the wiſe Creator hath made for the good of the animal world; and that is, the methods which all animals naturally take for their ſelf-preſervation and ſafety. And here it is remarkable, as in the caſes before, that man, who is endowed with reaſon, is born without armature, and is deſtitute of many powers, which irrational creatures have in a much higher degree than he, by reaſon he can make himſelf arms to defend himſelf, can contrive methods for his own guard and ſafety, can many ways annoy his enemy, and ſtave off the harms of noxious creatures.

But for others, who are deſtitute of this ſupereminent faculty; they are ſome way or

other

other provided with ſufficient guard [q], proportionate to their place of abode, the dangers they are like to incur there [r]; and, in a word, to their greateſt occaſions and need of ſecurity. Accordingly, ſome are ſufficiently guarded againſt all common dangers, by their natural clothing;

---

[q] ‘Callent in hoc cuncta animalia, ſciuntque non ſua modo commoda, verum et hoſtium adverſa; norunt ſua tela, norunt occaſiones, parteſque diffidentium imbelles. In ventre mollis eſt tenuiſque cutis crocodilo: ideoque ſe, ut territi, mergunt delphini, ſubeunteſque alvum illa ſecant ſpina. Plin. Nat. Hiſt. l. viii. c. 25.

[r] ‘Omnibus aptum eſt corpus animæ moribus et facultatibus: equo fortibus ungulis et juba eſt ornatum (etenim velox et ſuperbum et generoſum eſt animal.) Leoni, autem, utpote animoſo et feroci, dentibus et unguibus validum. Ita autem et tauro et apro; illi enim cornua, huic exerti dentes——— Cervo autem et lepori, timida enim ſunt animalia, velox corpus, ſed inerme. Timidis enim velocitas, arma audacibus conveniebant—Homini autem, ſapiens enim eſt—, manus dedit, inſtrumentum ad omnes artes neceſſarium, paci non minus quam bello idoneum. Non igitur indiguit cornu ſibi innato, cum meliora cornibus arma manibus, quandocunque volet, poſſit accipere: etenim enſis et haſta majora ſunt arma et ad incidendum promptiora——Neque cornu neque ungulæ quicquam niſi cominus agere poſſunt; hominum vero arma eminus juxta ac cominus agunt: telum quidem et ſagitta magis quam cornua. —Non igitur eſt nudus, neque inermis——ſed ipſi eſt thorax ferreus, quandocunque libet, omnibus coriis difficilius ſauciatu organum.---Nec thorax ſolum ſed et domus, et murus, et turris,’ &c. Galen. de uſu Part. l. 1, c. 2.

by their armature of ſhells, or ſuch like hard, and impregnable covering of their body [f]. Others deſtitute of this guard, are armed, ſome with horns [t], ſome with ſharp quills and prickles [u],

---

[f] Shells deſerve a place in this ſurvey, upon the account of their great variety! the curious and uncouth make of ſome, and the beautiful colours, and pretty ornaments of others; but it would be endleſs to deſcend to particulars. Omitting others, I ſhall therefore only take notice of the tortoiſe-ſhell, by reaſon a great deal of dexterity appears, even in the ſimplicity of that animal's ſkeleton. For, beſides that the ſhell is a ſtout guard to the body, and affords a ſafe retreat to the head, legs and tail, which it withdraws within the ſhell upon any danger; beſides this, I ſay, the ſhell ſupplieth the place of all the bones in the body, except thoſe of the extreme parts, the head and neck, and the four legs and tail. So that at firſt ſight, it is ſomewhat ſurprizing to ſee a complete ſkeleton conſiſting of ſo ſmall a number of bones, and they abundantly ſufficient for the creature's uſe.

[t] Dente timentur apri: defendunt cornua tauros;
Imbelles Damæ quid niſi præda ſumus?
Martial. l. 13. Epigr. 94.

[u] The hedge-hog being an helpleſs, ſlow, and patient animal, is accordingly guarded with prickles and a power of rolling itſelf up in them. 'Clavis, terebrari ſibi pedes, et diſcindi 'viſcera patientiſſime ferebat, omnes cultri ictus ſine gemitu 'pluſquam Spartana nobilitate concoquens. Borrichius in Blaſ. 'de Echino. Panniculum carnoſum amplexabatur muſculus pene 'circularis admirandæ, fabricæ, lacinias ſuas ad pedes, caudam, 'caput, varie exporrigens, cujus miniſterio echinus ſe ad arbitrium in orbem contrahit.' Act. Dan. in Blaſio.

Iſte licet digitos teſtudine pungat acuta,
Cortice depoſito mollis echinus erit. Mart. l. 13. Epig. 86.

ſome

ſome with claws, ſome with ſtings [w]; ſome can ſhift and change their colours [x]; ſome can make their eſcape by the help of their wings, and others by the ſwiftneſs of their feet; ſome can ſcreen themſelves by diving in the waters, others by tinging and diſordering the waters [y], can

---

[w] The ſting of a waſp, or bee, &c. is ſo pretty a piece of work, that it is worth taking notice of, ſo far as I have not found others to have ſpoken of it. Others have obſerved the ſting to be an hollow tube, with a bag of ſharp penetrating juices; its poiſon, joined to the end of it, within the body of the waſp, which is, in ſtinging, injected into the fleſh through the tube. But there are, beſides this, two ſmall, ſharp, bearded ſpears, lying within this tube, or ſting, as in a ſheath. In a waſp's ſting, I counted eight beards on the ſide of each ſpear, ſomewhat like the beards of fiſh hooks. Theſe ſpears in the ſting, or ſheath, lie one with its point a little before that of the other; as is repreſented in Fig. 21. to be ready, I conceive, to be firſt darted into the fleſh; which being once fixed, by means of its foremoſt beard, the other then ſtrikes in too, and ſo they alternately pierce deeper and deeper, their beards taking more and more hold in the fleſh; after which the ſheath or ſting follows, to convey the poiſon into the wound. Which, that it may pierce the better, it is drawn into a point, with a ſmall ſlit a little below that point, for the two ſpears to come out at. By means of this pretty mechaniſm in the ſting, it is that the ſting, when out of the body, and parted from it, is able to pierce and ſting us: and by means of the beards being lodged deep in the fleſh, it comes to paſs that bees leave their ſtings behind them, when they are diſturbed, before they have time to withdraw their ſpears into their ſcabbard. In Fig. 21. is repreſented the two ſpears as they lie in the ſting. In Fig. 22. the two ſpears are repreſented when ſqueezed out of the ſting, or the ſcabbard; in which latter, Fig. A c b, is the ſting; c d, and b e, the two bearded ſpears thruſt out.

[x] The cameleon is ſufficiently famed on this account. Beſides which, Pliny tells us of a beaſt as big as an ox, called the tarandus,

---

tarandus, that when he pleaſeth, aſſumes the colour of an aſs, and 'Colorem omnium fruticum, arborum, florum, locorum-'que reddit, in quibus latet metuens, ideoque raro capitur. Plin. l. 8. c. 34.

How true this is, there may be ſome reaſon to doubt; but, if any truth be in the ſtory, it may be from the animals chuſing ſuch company, or places, as are agreeable to its colour: as I have ſeen in divers caterpillars, and other inſects, who, I believe, were not able to change their colour, from one colour to another; yet I have conſtantly obſerved, do fix themſelves to ſuch things as are of the ſame colour? by which means they dodge the ſpectator's eye. Thus the caterpillar that feeds on elder, I have more than once ſeen, ſo cunningly adhering to the ſmall branches of the ſame colour, that it might be eaſily miſtaken for a ſmall ſtick, even by a careful view. So a large green caterpillar, that feeds on buckthorn, and divers others. To which I may add, the prodigious ſagacity of the ichneumon flies, that make the kermes, for of that tribe all the kermes I ever ſaw were; how artificially they not only incloſe their eggs within that gummy ſkin, or ſhell, but alſo ſo well humour the colour of the wood they adhere to, by various ſtreaks and colours, that it is not eaſy to diſtinguiſh them from the wood itſelf.

[y] 'Contra metum et vim, ſuis ſe armis quæque defendit. 'Cornibus tauri, apri dentibus, morſu leones, aliæ fuga ſe 'aliæ occultatione tutantur: atramenti effuſione ſepiæ, torpore torpedines. Multæ etiam inſectantes odoris intolerabili fœditate depellunt.' Cic. de Nat. Deor. l. 2. c. 50.

make their eſcape; and ſome can guard their bodies, even in the very flames, by the ejection of the juice of their bodies [z]; and ſome by their accurate ſmell, ſight, or hearing, can foreſee dangers [a]; others, by their natural craft, can prevent or eſcape them [b]; others by their uncouth noiſe [c]; by the horrid aſpect, and ugly geſticulations of their body [d]; and ſome even by the power of their excrements, and their ſtink[e], can annoy their enemy, and ſecures themſelves; and againſt ſome

---

[z] A knight, called Borvini, at Rome, caſt a ſalamander into the fire, which preſently ſwelled, and then vomited ſtore of thick ſlimy matter, which put out the coals; to which the ſalamander preſently retired, putting them out again in the ſame manner, as ſoon as they re-kindled, and by this means ſaved itſelf from the force of the fire, for the ſpace of two hours; after which it lived nine months. Vide Phil. Tranſ. N° 21. in Lowth. Abrig. vol. 2. p. 816.

[a] Pliny gives an inſtance in each, l. 10. c. 69. 'Aquilæ 'clarius cernunt [quam homines]; vultures ſagacius odoran- 'tur, liquidius audiunt talpæ obrutæ terra, tam denſo atque 'ſurdo naturæ elemento.'

[b] The doublings of the hare, before ſhe goes to form, thereby to dodge and deceive the dogs, although a vulgar obſervation, is a notable inſtinct for an animal, leſs famed for cunning than the fox, and ſome others.

[c] It is natural for many quadrupeds, birds, and ſerpents, not only to put on a torvous angry aſpect, when in danger, but alſo to ſnarl, hiſs, or by ſome other noiſe deter their adverſary.

[d] The iynx, or wryneck, although a bird of very beautiful feathers, and conſequently far enough off from being any way terrible;

---

terrible; yet, being in danger, hath ſuch odd contortions of its neck; and motions of its head, that I remember have ſcared me, when I was a boy, from taking their neſts, or touching the bird, daring no more to venture my hand into their holes, than if a ſerpent had lodged in it.

[e] ‘Bonaſus tuetur ſe calcibus et ſtercore, quod ab ſe quaternis paſſibus [trium jugerum longitudine. Plin. Nat. Hiſt. l. 8. c. 15.] ejaculatur, quod ſæpe comburit adeo ut deglabrentur canes.’ Ray's Synopſ. Quadr. p. 71.

‘Camelus Peruvianus clama dictus neminem offendit, ſed miro admodum ingenio ſe ab illata vindicat injuria, nimirum vomitu vel cibi, humoris in vexantem retrorſum cum impetu ejaculato, ob protenſam colli longitudinem.’ Id. ib. p. 146.

‘Tzquiepati, (Anglice Squnck, Præf. and one that I ſaw they called a Stonck,) ‘Cum quis eam inſectatur, fundit cum ventris crepitu halitum fœtidiſſimum: quia ipſa tota teterrimum exhalat odorem, et urina ſtercuſque eſt foetidiſſimum, atque adeo peſtilens, ut nihil ſit reperire in noſtro orbe, cui in hac re poſſit comparari: quo ſit, ut in periculo conſtituta, urinam et fæces ad 8 pluriumve paſſuum intervallum ejiciat, hoc modo ſe ab omnibus vindicans injuriis, ac veſtes inficiens maculis luteis indelibilibus, et nunquam ſatis perſpirante odore: alias innoxium animal eduleque, hac ſola ratione horrendiſſimum.’ Id, ib. p. 182.

‘Si accipiter ardeam in ſublimi moleſtat, ſtercore immiſſo in pennas ejus, eas putreſcere facit: uti Solinus ſcribit de Bonaſo, &c. Ita et lupus urinam ſpargit in perſequentem.’ Ol. Mag. Hiſt. l. 19. c. 14.

the

[f] the divine providence itſelf hath provided a guard.

By ſuch ſhifts and means as theſe, a ſufficient guard is miniſtered to every ſpecies of animals, in its proper reſpective place; abundantly enough to ſecure the ſpecies from deſtruction, and to keep up that balance, which I have formerly ſhewed, is in the world, among every, and all the ſpecies of animals; but yet not enough to ſecure individuals from becoming a prey to man, or to other creatures, as their neceſſities of life require. To which purpoſe the natural ſagacity and craft of the one intrapping, and captivating, being in ſome meaſure equivalent to that of the other in evading, is as excellent a means for the maintaining the one, as preſerving the other; and, if well conſidered, argues the contrivances of the infinitely wiſe Creator and preſerver of the world.

---

[f] Thus againſt the crocodile, which can catch its prey only before it, not on one ſide. So the ſhark, of which take my often-commended friend Sir Hans Sloane's obſervation; 'It has 'this peculiar to it, with ſome others of its own tribe, that the 'mouth is in its under parts, ſo that it muſt turn the belly up'wards to prey. And was it not for that time it is in turning, 'in which the purſued fiſhes eſcape, there would be nothing that 'could avoid it; for it is very quick in ſwimming, and hath a 'vaſt ſtrength, with the largeſt ſwallow of any fiſh, and is very 'devouring.' Sloane's Voy. to Jamaica, p. 23.

CHAP. XV.

OF THE GENERATION OF ANIMALS.

THERE remains now only one thing more of the ten things in common to animals, and that is what relates to their generation [g], and con-frogs were, and that they dropped down in ſhowers of rain. For an anſwer to this caſe of frogs, I ſhall refer to a relation of my own, which my late moſt ingenious and learned friend, the great Mr. Ray, requeſted of me, and was pleaſed to publiſh in his laſt edition of his Wiſdom of God manifeſted, &c. p. 365.

---

[g] Spontaneous generation is a doctrine ſo generally exploded, that I ſhall not undertake the diſproof of it. It is evident, that all animals, yea, vegetables too, owe their production to parent animals, and vegetables; that I have often admired at the ſloth and prejudices of the antient philoſophers, in ſo eaſily taking upon truſt the Ariſtotelian or rather the Egyptain doctrine of equivocal generation; that when they ſaw flies, frogs, and lice, for inſtance, to be male and female, and accordingly to ingender, lay eggs, &c. they could ever imagine any of theſe creatures ſhould be ſpontaneouſly produced, eſpecially in ſo romantic a manner, as in the clouds; as they particularly thought

But ſome will yet aſſert the raining of frogs; among which the curious Dr. Plot is ſomewhat of this opinion; telling us of frogs found on the leads of the lord Aſton's gate-houſe, at Tixal in Staffordſhire, which he thinks by ſome ſuch means came there; as alſo on the bowling-green, frequently after a ſhower of rain. Plot's Hiſt. Staff. c. 1. ſect. 47.

But we may take a judgment of this, and an hundred ſuch like reports, to be met with in conſiderable authors, from other the like reports that have been better inquired into. In a ſcarcity in Sileſia, a mighty rumour was ſpread of its raining millet-ſeed; but the matter being inquired into, it was found to be only the ſeeds of the ivy-leaved ſpeedwell, or ſmall henbit, growing in the place in great plenty. Eph. Germ. An. 3, Obſ. 40. So in the Archipelago, it was thought aſhes were rained, ſhips being covered therewith at a hundred leagues diſtance: but in all probability, it was from an eruption of Veſuvius, that then happened. About Warminſter in Wilts, it was reported it rained wheat; but a curious obſerver, Mr. Cole, found it to be only ivy-berries, blown thither in a conſiderable quantity by a tempeſt. In the year 1696, at Cranſtead near Wrothan in Kent, a paſture-field was over-ſpread with little young whitings, ſuppoſed to fall from the clouds, in a tempeſt of thunder and rain; but doubtleſs they were brought thither with waters from the ſea by the tempeſt. See the before-commended Mr. Low. Abrig. Phil. Tranſ. vol. ii. p. 143, 144.

Neither needeth it ſeem ſtrange, that aſhes, ivy-berries, ſmall fiſhes, or young frogs, (which yet may have ſome other conveyance,) ſhould be thus tranſported by tempeſtuous wind, conſidering, to what diſtance, and in what quantities, the ſea waters were carrried by the great ſtorm, Nov. 26, 1703, of which an in-

ingenious friend ſent me theſe accounts from Lewes in Suſſex, viz. ‘ That a phyſician travelling ſoon after the ſtorm, to Tiſe-
‘ hurſt, twenty miles from the ſea, as he rode along plucked ſome
‘ tops of hedges, and chewing them, found them ſalt : that ſome
‘ grapes hanging on the vines at Lewes, were ſo too : that Mr.
‘ Williamſon, rector of Ripe, found the twigs in his garden ſalt
‘ the Monday after the ſtorm ; and others obſerved the ſame a
‘ week after. That the graſs of the downs about Lewes was ſo
‘ ſalt, that the ſheep would not feed till hunger compelled them ;
‘ and that the miller of Berwick, three miles from the ſea, at-
‘ tempting, with his man, to ſecure his mill, were ſo waſhed with
‘ flaſhes of ſea water, like the breakings of waves againſt the
‘ rocks, that they were almoſt ſtrangled therewith, and forced
‘ to give over their attempt.’

I called the doctrine of equivocal generation, an Egyptian doctrine, becauſe probably it had its riſe in Egypt, to ſolve the hypotheſis of the production of men, and other animals, out of the earth, by the help of the ſun's heat. To prove which, the Egyptians, as Diod. Sicul. ſaith, produceth this obſervation, ‘ That about Thebes, when the earth is moiſtened by the Nile, ‘ by the intenſe heat of the ſun, an innumerable number of ‘ Mice do ſpring out.’ From whence he infers, that all kinds of animals, might as well at firſt come likewiſe out of the earth. And from theſe the learned biſhop Stillingfleet thinks other writers, as Ovid, Mela, Pliny, &c. have, without examining its truth, taken up the ſame hypotheſis. Vide Stillingfleet's Orig. Sacr. part 2. book i. chap. 1.

The before-commended Dr. Harris, from the obſervations of Dr. Harvey, S. Malpighi, Dr. De Graaf, and Mr. Leewenhoeck, infers three things concerning generation, as highly probable. 1. ‘ That animals are ex animalculo. 2. That the animalcules are ‘ originally in ſemine marium, et non in fœminis. 3. That they ‘ can never come forward, or be formed into animals of the re-‘ ſpective kind, without the ova in feminis.’ His proofs and illuſtrations. ſee under the word Generation, in his Lex. Tech. v 2.

‘ At

converſation of their ſpecies [h], by that means. I would not be ſeemly to advance far in this admirable work of God; neither ſhall I at all inſiſt upon that of man, for the ſame reaſon. And as for the irrationals [i], I ſhall confine myſelf to theſe five matters.

I. Their natural ſagacity in chuſing the fitteſt places to repoſite their eggs and young.

II. The fitteſt times and ſeaſons they make uſe of for their generation.

III. The due and ſtated number of their young.

IV. Their diligence and earneſt concern in their breeding up.

V. Their faculty of feeding them, and their art and ſagacity exerted therein.

---

[h] 'At certo natura, ſi fieri potuiſſet, maxime optaſſet ſuum opificium eſſe immortale: quod cum per materiam non liceret (nam quod——ex carne eſt compoſitum, incorruptibile eſſe non poteſt) ſubſidium quod potuit ipſi ad immortalitatem eſt fabricata, ſapientis cujuſdam urbis conditoris exemplo, &c. Nam mirabilem quandam rationem invenit, quomodo in demortui animalis locum, novum aliud ſufficiat.' Gal. de uſu Part. l. 14. c. 22.

[i] 'Animantia bruta obſtetricibus non indigent in edendo partu, cum indita naturæ vi umbilicus ſeipſum occludat.' Ol. Rudbeck in Blaſii Anat. Felis.

I. The natural ſagacity of irrational animals, in chuſing the fitteſt places to repoſite their eggs and young. Of this I have given larger hints already than I needed to have done, when I ſpake of the architecture[k] of animals, intending then to have wholly paſſed by this buſineſs of generation: I ſhall therefore now only ſuperadd a few other inſtances, the more to illuſtrate this matter.

It hath been already ſhewn, and will hereafter[l] farther appear, that the places in which the ſeveral ſpecies of animals lay up their eggs, and young, are the beſt for that purpoſe; waters[m] for one; fleſh for another; holes in wood [n], earth, or ſtone [o]. for others; and neſts for others; and we ſhall find, that ſo ardent is the propenſity of all animals, even of the meaneſt inſects, to get a fit place for the propagation of their young, that, as will hereafter appear, there is ſcarce any thing that eſcapeth the inqueſt of thoſe little ſubtle creatures. But beſides all this, there are two or three things more obſervable, which plainly argue the inſtinct of ſome ſuperior being. As,

---

[k] Chap. 13.

[l] Book viii. chap. 6.

[m] The ephemeron, as it is an unuſual and ſpecial inſtance of the brevity of life, ſo I take it to be a wonderful inſtance of the ſpecial care and providence of God, in the conſervation of the ſpecies of that animal. For, 1. As an animal, whoſe life is determined in about five or ſix hours time, viz. (from about ſix in the evening, till about eleven o'clock at night,) needs no food; ſo neither doth the ephemeron eat, after it is become a fly. 2. As to its generation; in thoſe five hours of its life, it performs that, and all other neceſſary offices of life: for in the beginning of its life, it ſheds its coat; and that being done, and the poor little animal thereby rendered light and agile, it ſpends the reſt of its ſhort time in friſking over the waters, and at the ſame time the female droppeth her eggs on the waters, and the male his ſperm on them, to impregnate them. Theſe eggs are ſpread

1. The complete and neat order which many creatures obſerve in laying up their ſeed, or eggs in proper repoſitories; of which I ſhall ſpeak in another place [p].

ſpread about by the waters? deſcend to the bottom by their own gravity; and are hatched by the warmth of the ſun, into little worms, which make themſelves caſes in the clay, and feed on the ſame without any need of parental care. Vide Ephem. vita, tranſlated by Dr. Tyſon from Swammerdam. See alſo book viii. chap. 6.

[n] See chap. 13. and book viii. chap. 6.

[o] The worms in chap. 11. breed in the holes they gnaw in ſtone, as is manifeſt from their eggs found therein.

[p] See book viii. chap. 6

2. The ſuitable apparatus in every creature's body, for the laying up its eggs, ſeed or young in their proper place. It would be as endleſs as needleſs to name all particulars, and therefore an inſtance or two of the inſect tribe may ſerve for a ſpecimen in this place, till I come to other particulars. Thus inſects, who have neither feet adapted to ſcratch, nor noſes to dig, nor can make artificial neſts to lay up their young; yet what abundant amends is there made them, in the power they have either to extend the abdomen [q], and thereby

---

[q] Many, if not moſt flies, eſpecially thoſe of the fleſh-fly-kind, have a faculty of extending their uropygia, and thereby are enabled to thruſt their eggs into convenient holes and receptacles for their young, in fleſh, and whatever elſe they fly-blow; but none more remarkable than the horſe fly, called by Pennius in Mouffet, (p. 62.) Σκολιοῦρος; &c. Curvicauda, and the whame or burrel-fly, which is vexatious to horſes in ſummer, not by ſtinging them, but only by their bombylious noiſe, or tickling them, in ſticking their nits, or eggs on the hair: which they do in a very dexterous manner, by thruſting out their uropygia, bending them up, and by gentle, ſlight touches, ſticking the eggs to the hair of the legs, ſhoulders, and necks commonly of horſes; ſo that horſes which go abroad, and are ſeldom dreſſed, are ſomewhat diſcoloured by the numerous nits adhering to their hair.

Having mentioned ſo much of the generation of this inſect, although it be a little out of the way, I hope I ſhall be excuſed for taking notice of the long-tailed maggot, which is the product of theſe nits or eggs, called by Dr. Plot, eruca, glabra, [or rather eula ſcabra, it ſhould be] caudata aquatico-arborea, it being found by him in the water of an hollow-tree; but I have found it in ditches, thereby reach the commodious places they could not otherwiſe come at; or elſe they have ſome aculeous part or inſtrument to terebrate, and make way for their eggs into the root [r], trunk [s], fruit

ſaw-pits, holes of water in the high-way, and ſuch like places, where the waters are moſt ſtill and foul. This maggot I mention, as being a ſingular and remarkable work of God, not ſo much for its being ſo utterly unlike as it is to its parent bee-like fly, as for the wiſe proviſion made for it by its long tail; which is ſo jointed at certain diſtances from the body, as that it can be withdrawn, or ſheathed, one part within another, to what length the maggot pleaſeth, ſo as to enable it to reach the bottom of very ſhallow, or deeper waters, as it hath occaſion, for the gathering of food. At the end of this tapering is a ramification of fibrillæ, or ſmall hairs, repreſenting, when ſpread, a ſtar; with the help of which, ſpread out on the top of waters, it is enabled to hang, making, by that means, a ſmall depreſſion or concavity on the ſurface of the water. In the midſt of this ſtar, I imagine the maggot takes in air, there being a perforation, which, with a microſcope, I could perceive to be open, and by the ſtar to be guarded againſt the incurſion of the water.

[r] The excreſcences on the root of cabbages, turneps, and divers others plants, have always a maggot in them; but what the animal is that thus makes its way to the root under ground, whether ichneumon, phalæna, ſcarab, or ſcolopendra, I could never diſcover, being not able to bring them to any thing in boxes.

[s] I preſume there are only of the ichneumon-fly-kind, that have their generation in the trunks of vegetables. In Malpighi de Gallis, fig. 61. is a good cut of the gouty excreſcences, or rather tumours, of the briar-ſtalk, from which proceeds a ſmall black ichneumon fly with red legs; black, ſmooth jointed antennæ; pretty large thorax and ſhort, round belly, in the ſhape of an heart. It leapeth as a flea. The male, as in other inſects, is leſſer than the female, and very venereous,

fruit [t], leaves [u], and the tender buds of vegetables

---

venerous in ſpite of danger, getting upon the female, whom they beat and tickle with their breeches and horns to excite them to a coit.

Another example of the generation in the trunks of vegetables, ſhall be from the papers of my often-commended friend Mr. Ray, which are in my hands, and that is an obſervation of the ingenious Dr. Nathaniel Wood. 'I have, ſaid he, lately obſerved many eggs, 'in the common ruſh; one ſort are little tranſparent eggs, in ſhape 'ſomewhat like a pear, or retort, lying within the ſkin, upon or in 'the medulla, juſt againſt a browniſh ſpot on the outſide of the 'ruſh; which is apparently the creatrix of the wound made by the 'fly, when ſhe puts her eggs there. Another kind is much longer, 'and not ſo tranſparent, of a long oval, or rather cylindrical form; 'ſix, eight, or more, lie commonly together acroſs the ruſh, parallel 'to each other, like the teeth of a comb, and are as long as the breadth 'of the ruſh.' Letter from Kilkenny in Ireland, April the 28th, 1697.

[t] See book viii. chap. 6.

[u] I have, in chap. 13. book viii. and chap. 6. taken notice of the nidification and generation of ſome inſects, on the leaves of vegetables, and ſhall therefore, for the illuſtration of this place, chuſe an uncommon example out of the ſcarab-kind (the generation of which tribe hath not been as yet mentioned) and that is, of a ſmall ſcarab bred in the very tips of elm leaves. Theſe leaves, in ſummer, may be obſerved to be many of them, dry and dead, as alſo turgid; in which lieth a dirty, whitiſh, rough maggot. From which proceeds a beetle of the ſmalleſt kind, of a light, weeſel colour, that leapeth like a graſhopper, although its legs are but ſhort. Its eyes are blackiſh, elytra thin, and prettily furrowed, with many concavities in them; ſmall clubheaded, antennæ, and a long roſtrum like a proboſcis.

ables[x], or ſome other ſuch curious and ſecure method they are never deſtitute of. To which we may add,

3. The natural poiſon[y], or what can I call it? which many, or moſt of the creatures, laſt intended, have, to cauſe the germination of ſuch balls, caſes, and other commodious repoſitories, as are an admirable lodgement to the eggs and young; that particularly aſſiſt in the incubation and hatching the young, and then afford them ſufficient food and nouriſhment in all their nympha-ſtate, in which they need food; and are afterwards commodious houſes and beds for them in their aurelia-ſtate, till they are able to break priſon, fly abroad, and ſhift for themſelves. But this

---

The ſame, or much like this, I have met with on tips of oaken and holly leaves. How the ſcarab lays its eggs on the leaf, whether by terebrating the leaf, or whether the maggot, when hatched, doth it, I could never ſee. But with great dexterity it makes its way between the upper and under membranes of the leaf, feeding upon the parenchymous part thereof. Its head is ſlenderer and ſharper than moſt of maggots, as if made on purpoſe for this work; but yet I have often wondered at their artifice, in ſo nicely ſeparating the membranes of the elm-leaf, without breaking them, and endangering their own tumbling out of them, conſidering how thin, and very tender, the ſkins of that leaf particularly are.

[x] See book viii. chap. 6.

[y] See book viii. chap. 6.

this ſhall be taken notice of, when I come to treat of inſects.

II. As irrational animals chuſe the fitteſt place, ſo alſo the fitteſt times and ſeaſons for their generation. Some indeed are indifferent to all times, but others make uſe of peculiar ſeaſons[z]. Thoſe, for inſtance, whoſe proviſions are ready at all ſeaſons, or who are under the tuition of man, produce their young without any great regard to heat or cold, wet or dry, ſummer or winter. But others, whoſe proviſions are peculiar, and only to be met with at certain ſeaſons of the year; or who, by their migration, and change of place, are tied up to certain ſeaſons; theſe (as if endowed with a natural care and foreſight of what ſhall happen) do accordingly lay, hatch, and nurſe up their young in the moſt proper ſeaſons of all the year for their purpoſe; as in ſpring, or ſummer, the times of plenty of proviſions, the times, of warmth for incubation, and the moſt proper ſeaſons to breed up their young, till they are able to ſhift for themſelves, and can range about for food, and ſeek places of retreat and ſafety, by flying long flights as well as their progenitors, and paſſing into far diſtant regions, which, when others fail, afford thoſe helpleſs creatures the neceſſaries of life.

---

[z] Πολλὰ δὲ καὶ πρὸς ἐκτροφὰς τῶν τέκνων στοχαζόμενα, ποιοῦνται τὸν συνδυασμὸν ἐν τῃ ἀπαρτιζούσῃ ὥρᾳ. Ariſt. Hiſt. An. l. 5. c. 8. ubi plura.

III. To the ſpecial ſeaſons, I may add the peculiar numbers of young produced by the irrational creatures. Of which I have already taken ſome notice, when I ſpake of the balance of animals [a]. Now, if there was not a great deal more than chance in this matter, even a wiſe government of the creation, it could never happen that every ſpecies of animals ſhould be tied up to a certain rate and proportion of its increaſe; the moſt uſeful would not be the moſt fruitful, and the moſt pernicious produce the feweſt young, as I have obſerved it commonly is. Neither would every ſpecies produce ſuch a certain rate as it is only able to breed up; but all would be in a confuſed, huddled ſtate. Inſtead of which on the contrary, we find every thing in complete order; the balance of genera, ſpecies and individuals always proportionate and even; the balance of ſexes the ſame; moſt creatures tied up to their due ſtint and number of young, without their own power and choice, and others (particularly

[a] See chap. x.

ticularly of the winged [b] kind,) producing their due number at choice and pleaſure; ſome large numbers, but not more than they can cover, feed and foſter; others fewer, but as many as they can well nurſe and breed up. Which minds me,

IV. Of the diligence and earneſt concern which irrational animals have of the production and breeding up their young. And here I have already taken notice of their Στοργὴ, or natural affection, and with what zeal they feed and defend their young. To which may be added theſe two things:

1. The wonderful inſtinct of incubation. It is utterly impoſſible, that ever unthinking, untaught animals ſhould take to that only method of hatching their young, was it not implanted in their nature by the infinitely wiſe Creator. But ſo ardent is their deſire, ſo unwearied is their

---

[b] Mr. Ray alleges good reaſon to conclude, that although birds have not an exact power of numbering, yet, that they have of diſtinguiſhing many from few, and knowing when they come near to a certain number; and that they have it in their power to lay many or few eggs. All which he manifeſteth from hens, and other domeſtic fowls, laying many more eggs when they are withdrawn, than when not. Which holds in wild as well as domeſtic birds, as appears from Dr. Liſter's experiment in withdrawing a ſwallow's egg, which by that means laid nineteen eggs ſucceſſively before ſhe gave over. Vide Ray's Wiſdom of God, &c. p. 137.

patience, when they are engaged in that buſineſs, that they will abide in their neſts for ſeveral weeks, deny themſelves the pleaſures, and even the neceſſaries of life; ſome of them even ſtarving themſelves almoſt, rather than hazard their eggs, to get food; and others either performing the office by turns [c], or elſe the one kindly ſeeking out, and carrying food to the other [d], engaged in the office of incubation. But of theſe matters in a more proper place [e].

2. When the young ones are produced, not only with what care do they feed and nurſe them; but with what ſurprizing courage do all or moſt creatures defend them! It is ſomewhat ſtrange to

---

[c] 'Palumbes incubat fœmina poſt meridiana in matutinum, cætero 'mas. Columbæ incubant ambo, interdiu mas, noctu fœmina.' Plin. Nat. Hiſt. l. 10. c. 58.

[d] Of the common crow, Mr. Willoughby ſaith, 'The females 'only ſit, and that diligently, the males in the mean time bring them 'victuals; as Ariſtotle ſaith. In moſt other birds, which pair to'gether, the male and female ſit by turns.' Ornithol. l. 2. ſect. 1. c. 2. ſect. 2. And I have obſerved the female-crows to be much fatter than the males, in the time of incubation; by reaſon the male, out of his conjugal affection, almoſt ſtarves himſelf to ſupply the female with plenty.

[e] See book vii. chap. 4.

ſee timid creatures [f], who at other times are cowardly, to be full of courage, and undaunted at that time; to ſee them furiouſly and boldly encounter their enemy, inſtead of flying from him; and expoſe themſelves to every danger, rather than hazard and forſake their young.

With this earneſt concern of the irrational animals for their young, we may join in the

V. And laſt place, their faculty and ſagacity of feeding them. About which I ſhall take notice of three things:

1. The faculty of ſuckling the young is an excellent proviſion the Creator hath made for thoſe helpleſs creatures. And here the agreeableneſs and ſuitableneſs of that food to young creatures deſerves particular obſervation; as alſo their delight in it, and deſire and endeavours after it, even as ſoon as born [g], together with the willingneſs

---

[f] 'Volucribus natura novam quandam, pullos educandi, rationem excogitavit; ipſis enim præcipuum quendam amorem in ea quæ procrearent, ingeneravit, quo impulſu bellum pro pullis cum ferocibus animalibus, quæ ante declinarunt, intrepide ſuſcipiunt, victumque ipſis convenientem ſuppeditant.' Galen de uſa Part. l. 14. c. 4.

[g] 'In iis animantibus quæ lacte aluntur, omnis fere cibus matrum lacteſcere incipit, eaque, quæ palo ante nata ſunt, ſine magiſtra

neſs of all, even the moſt ſavage and fierce animals, to part with it, and to adminiſter it to their young, yea, to teach and inſtitute them in the art of taking it.

And laſtly, to name no more, the curious apparatus which is made for this ſervice in the divers ſpecies of animals, by a due number of breaſts, proportionable to the occaſions of each animal, by curious glands in thoſe breaſts, to ſeparate that nutritive juice, the milk, by arteries and veins to convey it to them, and proper rivulets and channels to convey it from them, with dugs and nipples, placed in the moſt convenient part of the body[h] of each animal, to adminiſter

---

' giſtro, duce natura, mammas appetunt, earumque ubertate ſaturantur. Atque ut intelligamus nihil horum eſſe fortuitum, et hæc ' omnia eſſe providæ, ſolertiſque naturæ, quæ multiciplices fœtus ' procreant, ut ſues, ut canes, his mammarum data eſt multitudo; ' quas eaſdem paucas habent eæ beſtiæ, quæ pauca gignunt.' Cic de Nat. Deor. l. 2. c. 51. Conſule quoque Galen. de uſu Part. l. 14. c. 4. & l. 15. c. 7.

[h] ' Animalia ſolidipeda et ruminantia, vel cornigera, inter femora ' mammas habent, quorum fœtus ſtatim a partu pedibus inſiſtunt, quod matres inter lactandum non decumbant ut equa, aſina, &c. ' Animalia digitata et multipara in medio ventre, ſcil. ſpatio ab inguine ad pectus, in cuniculo uſque ad jugulum, duplicem mammarum ſeriem ſortita ſunt, quæ omnia decumbentia ubera fœtibus ' admovent, ut urſa, leæna, &c. Si vero hæc in ſolo inguine mammas

miniſter it to their young; all theſe things, I ſay, do manifeſtly proclaim the care and wiſdom of the great Creator.

2. As for ſuch animals as do in another manner breed up their young, by finding out food, and putting it into their mouth, the proviſion made in them for this ſervice, to ſtrike, catch, to pouch and convey their prey and food to their young[i], is very conſiderable. And ſo is alſo their

---

' mas gererent, propria cura inter decumbendum fœtus acceſſum ad ' mammas nonnihil præpedirent. Mulieribus mammæ binæ ſunt, ut ' et papillæ, nimirum ut latus lateri conformiter reſpondeat, et ut ' alternatim infans a latere in latus inter ſugendum transferatur, ne ' corpus ejus uni lateri nimis aſſueſcens quoquo modo incurvetur. ' Simia, homo ſylveſtris,' &c. Blaſ. Anat. Animal. part. 1. c. 6. de cane ex Whartono. See here what Pliny hath alſo, l. 11. c. 40.

In the elephant, the nipples are near the breaſt, by reaſon the old one is forced to ſuck herſelf, and by the help of her trunk conveys the milk into the mouth of her young. Vide Phil. Tranſ. No. 356.

[i] For an exemplification, I might name many animals, particularly birds, whoſe parts are completely ſuited to this ſervice. They are characteriſtics of rapacious birds, to have aduncous bills and talons to hold and tear; and ſtrong brawny thighs to ſtrike and carry their prey; as well as a ſharp piercing ſight to eſpy it afar off. Raii Synopſ. Method. Av. p. 1. The pelican alſo might be here named, for its prodigious bag under its bill and throat; big enough to contain thirty pints. Id. ibid. p. 122. And, to name no more, the common heron hath its moſt remarkable parts adapted to this ſervice; long legs for wading; and a long neck anſwerable thereto

to

their ſagacity in equally diſtributing it among them, that among many, all ſhall be duly, equally, and in good order, fed.

3. There is yet another inſtinct remaining, of ſuch animals as can neither adminiſter ſuck to their young, neither lay them in places affording food, nor can convey and bring them food, but do with their eggs, lay up proviſions for their future young. Somewhat of this is reported of ſome birds[k]; but I have myſelf, with pleaſure, frequently ſeen ſome of the ſpecies of inſects to carry

---

to reach prey; a wide extenſive throat to pouch it; long toes, with ſtrong hooked talons, (one of which is remarkably ſerrate on the edge) the better to hold their prey; a long ſharp bill to ſtrike their prey; and ſerrate towards the point, with ſharp hooked beards ſtanding backward, to hold their prey faſt when ſtruck; and laſtly, large, broad, concave wings (in appearance much too large, heavy, and cumberſome for ſo ſmall a body,) but of greateſt uſe to enable them to carry the greater load to their neſts, at ſeveral miles diſtance; as I have ſeen them do from ſeveral miles beyond me, to a large heronry above three miles diſtant from me. In which I have ſeen plaiſe, and other fiſh, ſome inches long, lying under the high trees in which they build; and the curious and ingenious owner thereof, D'Acre Barret, Eſq; hath ſeen a large eel conveyed by them, notwithſtanding the great annoyance it gave them in their flight, by its twiſting this way and that way about their bodies.

[k] This is reported of the American oſtrich mentioned by Acarette, in Philoſ. Tranſ. No. 89. Of which ſee book vii. chap. 4.

carry ample proviſions into their dry and barren cells, where they have ſealed them carefully and cautiouſly up with their eggs, partly, it is like for incubation-ſake, and partly as an eaſy bed to lodge their young; but chiefly, for future proviſion for their young, in their nympha-ſtate, when they ſtand in need of food[1].

---

[1] Hornets, waſps, and all the kinds of bees provide honey; and many of the pſeudophecæ, and ichneumon waſps and flies, carry maggots, ſpiders, &c. into their neſts; of which ſee chap. 13.

CHAP.

CHAP. XVI.

THE CONCLUSION.

THUS I have, as briefly as I well could, (and much more briefly than the matters deſerved) diſpatched the decade of things I propoſed in common to the ſenſitive creatures. And now let us pauſe a little, and reflect. And upon the whole matter, what leſs can be concluded, than that there is a being infinitely wiſe, potent, and kind, who is able to contrive and make this glorious ſcene of things, which I have thus given only a glance of! For, what leſs than infinite could ſtock ſo vaſt a globe with ſuch a noble ſet of animals! all ſo contrived, as to miniſter to one another's help ſome way or other, and moſt of them ſerviceable to man peculiarly, the top of this lower world, and who was made, as it were, on purpoſe to obſerve, and ſurvey and ſet forth the glory of the infinite Creator, manifeſted in his works! Who? what but the great God, could ſo admirably provide for the whole animal world, every thing ſerviceable to it, or that can be wiſhed for, either to conſerve its ſpecies, or to miniſter to the being or well being of individuals! Particularly, who could feed ſo ſpacious a world, who could pleaſe ſo large a number of palates, or ſuit ſo many palates to ſo great a variety of food, but the infinite conſervator of the world! And who but the ſame great HE, could provide ſuch commodious clothing for every animal; ſuch proper houſes, neſts, and habitations; ſuch ſuitable armature and weapons; ſuch ſubtilty, artifice, and ſagacity, as every creature is more or leſs armed and furniſhed with, to fence off the injuries of the weather, to reſcue itſelf from dangers, to preſerve itſelf from the annoyances of its enemies; and, in a word, to conſerve itſelf, and its ſpecies! What but an infinite ſuperintending Power could ſo equally balance the ſeveral ſpecies of animals, and conſerve the numbers of the individuals of every ſpecies ſo even, as not to over or under-people the terraqueous globe! Who, but the infinite wiſe Lord of the world, could allot every creature its moſt ſuitable place to live in, the moſt ſuitable element to breathe, and move, and act in! And who, but HE, could make ſo admirable a ſet of organs, as thoſe of reſpiration are, both in land and water animals! Who could contrive ſo curious a ſet of limbs, joints, bones, muſcles, and nerves to give to every animal the moſt commodious motion to its ſtate and occaſions! And, to name no more, what anatomiſt, mathematician, workmen, yea, angel, could contrive and make ſo curious, ſo commodious, and every way ſo exquiſite a ſet of ſenſes, as the five ſenſes of animals are; whoſe organs are ſo dexterouſly contrived, ſo conveniently placed in the body, ſo neatly adjuſted, ſo firmly guarded, and ſo completely ſuited to every occaſion, that they plainly ſet forth the agency of the infinite Creator and conſervator of the world!

So that here, upon a tranſient view of the animal world in general only, we have ſuch a throng of glories, ſuch an enraviſhing ſcene of things, as may excite us to admire, praiſe, and adore the infinitely wiſe, powerful, and kind CREATOR; to condemn all atheiſtical principles; and with holy David, Pſalm xiv. v. 1. to conclude, that he is in good earneſt a fool, that dares to ſay, 'There is no God,' when we are every where ſurrounded with ſuch manifeſt characters, and plain demonſtrations, of that infinite Being.

But in the next book we ſhall ſtill find greater tokens, if poſſible, when I come to take a view of animals in particular.

A SURVEY

A SURVEY OF THE PARTICULAR TRIBES OF ANIMALS.

IN the foregoing book, having taken a view of the things in common to animals, my buſineſs, in the next, will be to inſpect the particular tribes, in order to give further manifeſtations of the infinite Creator's wiſdom, power, and goodneſs towards the animal world.

BOOK V.

A SURVEY OF MAN.

THE firſt genus of animals that I ſhall take notice of, ſhall be man, who may juſtly claim the precedence in our diſcourſe, inaſmuch as God hath given him the ſuperiority in the animal world. Gen. i. 26. ‘And God ſaid, Let us ‘make man in our image, after our likeneſs; ‘and let them have dominion over the fiſh of the ‘ſea, and over the fowl of the air, and over the ‘cattle, and over all the earth, and over every ‘creeping thing that creepeth upon the earth.’

And as to man, we have ſo excellent a piece of workmanſhip, ſuch a microcoſm, ſuch an abridgement of the Creator's art in him, as is alone ſufficient to demonſtrate the being and attributes of God. Which will appear, by conſidering the ſoul and the body of man.

CHAP. I.

OF THE SOUL OF MAN.

MY ſurvey of man I ſhall begin with the ſoul of man, by reaſon it is his moſt noble part[m], the copy of the divine image in us[n], in which we have enough to fill us with admiration of the munificence, power, and wiſdom of the infinite Creator[o], when we contemplate the noble faculties of this our ſuperior part, the vaſt reach and compaſs of its underſtanding, the prodigious quickneſs and piercingneſs of its thought, the admirable ſubtilty of its invention, the commanding power of its wiſdom, the great depth of its memory [p], and, in a word, its divine nature and operations.

---

[m] ‘Jam vera animum ipſum, mentemque hominis, rationem, con-
‘ ſilium prudentiam, qui non divina cura perfecta eſſe perſpicit, is
‘ his ipſis rebus mihi videtur carere. Cic. de Nat. Deor. l. 2. c. 59.

[n] Senſum a coeleſti demiſſum traximus arce,
Cujus egent prona, et terram ſpectantia: mundi
Principio indulſit communis conditor illis
Tantum animas; nobis animum quoque.
Juv. Sat. xv. ver. 144.
Et cum non aliter poſſent mortalia fingi,
Adjunxit geminas, illæ cum corpore lapſæ
Intereunt: hæc ſola manet, buſtoque ſuperſtes
Evolat. Claud. de 4 Conſul. Hon.

[o] ‘Nam ſiquis nulli ſectæ addictus, ſed libera ſententia rerum con-
‘ ſiderationem inierit, conſpicatus in tanta carnium ac ſuccorum
‘ colluvie tantam mentem habitare; conſpicatus item et cujuſvis ani-

But

'malis conſtructionem (omnia enim declarant opificis ſapientiam) 'mentis, quæ homini ineſt, excellentiam intelliget, tum opus de 'partium utilitate, quod prius exiguum eſſe ſibi videbatur, per-'fectiſſimæ theologiæ verum principium conſtituet: quæ theologia 'multo eſt major atque præſtantior tota medicinæ.' Galen de uſu Part. l. 17. c. 1.

[p] Among many examples that I could give of perſons famous for memory, Seneca's account of himſelf may be one: Hanc [memo-'riam] aliquando in me floruiſſe, ut non tantum ad uſum ſufficeret, 'ſed in miraculum uſque procederet, non nego. Nam et 2000 no-'minum recitata, quo ordine erant dicta, reddebam: et ab his qui 'ad audiendum preceptorem noſtrum convenerunt, ſingulos verſus 'a ſingulis datos, cum plures quam 200 efficerentur, ab ultimo in-'cipiens uſque ad primum recitabam.' After which, mention is made of the great memory of Latro Porcius, (chariſſime mihi ſodalis, Seneca calls him) who retained in his memory all the declamations he had ever ſpoken, and never had his memory fail him, not ſo much as in one ſingle word. Alſo, he takes notice of Cyneas, ambaſſador to the Romans, from King Pyrrhus, who in one day had ſo well learned the names of his ſpectators, that 'poſtero die novus homo 'et ſenatum, et omnem urbanam circumfuſam ſenatu plebem, no-'minibus ſuis perſalutavit.' Senec. Controverſ. l. 1. init. Vide quoque Plin. l. 7. c. 24. where he alſo adds other examples, viz. 'Cyrus rex omnibus in exercitu ſuo militibus nomina reddidit; L. Scipio populo Rom. Mithridates 22 gentium rex, totidem linguis

But I ſhall not dwell on this, though the ſuperior part of man, becauſe it is the leaſt known. Only there are two things I cannot eaſily paſs by; becauſe they manifeſt the ſpecial concurrence and deſign of the infinitely wiſe Creator, as having a particular and neceſſary tendency to the management and good order of the world's affairs. The

I. Of which is the various genii, or inclinations of mens minds to this, and that, and the other buſineſs[q]. We ſee how naturally men betake themſelves to this and that employment: ſome delight moſt in learning and books, ſome in

---

‘ jura dedit, pro concione ſingulas ſine interprete affatus, Charmidas,
‘ ſeu potius ~~Carneades~~,—quæ quis exegerat volumina in bibliothecis,
‘ legentis modo repreſentavit.’

[q] Diverſis etenim gaudet natura miniſtris,
Ut fieri diverſa queant ornantia terras.
Nec patitur cunctos ad eandem currere metam,
Sed varias jubet ire vias, varioſque labores
Suſcipere, ut vario cultu ſit pulchrior orbis.
Paling, in Scorp.

Οὕτως οὐ πάντεσσι Θεὸς χαρίεντα δίδωσι
Ἀνδράσιν, &c.

‘ Ita non omnibus hominibus ſua dona dat Deus, neque bonam ‘ indolem, neque prudentiam, nec eloquentiam; alius namque vul‘ tum habet deformem; ſed Deus formam eloquentia ornat,’ &c. Hom. Odyſ. 8. The like alſo in Iliad. l. 13.

in divinity, ſome in phyſic, anatomy, and botany, ſome in critical learning, and philology, ſome in mathematics, ſome in metaphyſics, and deep reſearches; and ſome have their delight chiefly in mechanics; architecture, war, navigation, commerce, agriculture; and ſome have their inclinations lie even to the ſervile offices of the world, and an hundred things beſides.

Now all this is an admirably wiſe, as well as moſt neceſſary proviſion, for the eaſy and ſure tranſacting the world's affair; to anſwer every end and occaſion of man, yea, to make man helpful to the poor helpleſs beaſts as far as his help is needful to them; and all, without any great trouble, fatigue, or great inconvenience to man; rather as a pleaſure and diverſion to him. For ſo far it is from being a toil, that the greateſt labours[r], cares, yea, and dangers too, become pleaſant to him who is purſuing his genius, and whoſe ardour of inclination eggs him forward, and buoys him up under all oppoſition, and carrieth him through every obſtacle, to the end of his deſigns and deſires.

---

[r] Although Solomon declares, Eccl. xii. 12. 'That much ſtudy 'is a wearineſs to the fleſh;' yet we ſee with what pleaſure and aſſiduity many apply themſelves to it. Thus Cicero tells of Cato, whom he uſually found in Lucullus's library; 'M. Catonem vidi 'in bibliotheca ſedentem, multis circumfuſum Stoicorum libris. 'Erat enim, ut ſcis, in eo inexhauſta aviditas legendi, nec ſatiari po-'terat: quippe ne reprehenſionem quidem vulgi inanem reformidans, 'in ipſa curia ſoleret legere ſæpe dum ſenatus cogeretur——ut Heluo 'librorum——videbatur.' Cic. de Finibus, l. 3. c. 2.

II. The next is, the Inventive power of the ſoul[s]. Under which I might ſpeak of many things; but I ſhall take notice only of two, becauſe they manifeſt the particular concern and agency of the infinitely wiſe Creator. The

1. Is, That man's invention ſhould reach to ſuch a great variety of matters; that it ſhould hit upon every thing that may be of any uſe, either to himſelf, or to human ſociety, or that may any ways promote, what in him lies, the benefit of this lower part of the creation.

For the illuſtration of this, I might take a view of all the arts and ſciences, the trades, yea, the very tools they perform their labours, and contrivances with, as numerous as their occaſions and contrivances are various. Indeed, what is there that falleth under the reach of man's ſenſes, that he doth not employ to ſome uſe and purpoſe, for the world's good? The celeſtial bodies, the ſun, the moon, with the other planets, and the fixed ſtars, he employs to the noble uſes of aſtronomy, navigation, and geography. And, what a noble acumen, what a vaſt reach muſt the ſoul be endowed with, to invent thoſe curious ſciences of geometry and arithmetic, both ſpecious, and in numbers; and thoſe nice and various inſtruments, made uſe of by the geometrician, aſtronomer, geographer, and ſailor! And laſtly, what a wonderful ſagacity is ſhewn in the buſineſs of optics, and particularly in the late invention of the teleſcope; wherewith new wonders are diſcovered among God's works, in the heavens, as there are here on earth, with the microſcope, and other glaſſes!

---

[s] 'Mentem hominis, quamvis eam non videas, ut Deum non vides, 'tamen ut deum agnoſcis en operibus ejus, ſic ex memoria rerum 'et inventione, et celeritate motus, omnique pulchritudine virtutis vim 'divinam mentis agnoſcito.' Cic. Tuſc. Quæſt. l. 1. c. 29.

And as for this lower world, what material is there to be found; what kind of earth, or ſtone, or metal; what animal, tree, or plant, yea, even the very ſhrubs of the field; in a word, what of all the excellent variety, the Creator has furniſhed the world with, for all its uſes and occaſions, in all ages; what I ſay, that man's contrivance doth not extend unto, and make ſome way or other advantageous to himſelf, and uſeful for building, clothing, food, phyſic, or for tools or utenſils, or for even only pleaſure and diverſion!

But now conſidering the great power and extent of human invention,

2. There is another thing, that doth farther demonſtrate the ſuper-intendence of the great Creator and conſervator of the world; and that is, that things of great, and abſolutely neceſſary uſe, have ſoon, and eaſily occurred to the invention of man; but things of little uſe, or very dangerous uſe, are rarely and ſlowly diſcovered, or ſtill utterly undiſcovered. We have as early as the Moſaic hiſtory, an account of the inventions of the more uſeful crafts and occupations: thus, Gen. iii. 23. 'Adam was ſent forth from 'the garden of Eden, by God himſelf, to till 'the ground.' And in the next chapter, his two ſons Cain and Abel; the one was of the ſame occupation, a tiller of the ground, the other a keeper of ſheep[t]. And the poſterity of theſe are in the latter end of Gen. iv. recorded, Jabal, 'to 'have been the father of ſuch as dwell in tents[u];' i. e. he was the inventor of tents, and pitching

---

[t] Gen. iv. 2.

[u] Ver. 20.

thoſe moveable houſes in the fields, for looking after, and depaſturing their cattle in the deſarts, and uncultivated world. '. Tubal-Cain was an 'inſtructor of every artificer in braſs and iron[v],' or the firſt that found out the art of 'melting, and 'malleating metals[w],' and making them uſeful for tools, and other neceſſary implements. And his ſiſter Naamah, whoſe name is only mentioned, is by ſome thought to have been the inventor of ſpinning and clothing. Yea, the very art of muſic is thus early aſcribed to Jubal[x]; ſo indulgent was the Creator to find a means to divert melancholy, to cheer the ſpirits, and to entertain and pleaſe mankind. But for things of no uſe, or but little uſe, or of pernicious conſequence, either they have been much later thought of, and with great difficulty, and perhaps danger too, brought to paſs; or elſe they ſtill are, and perhaps will always remain, exerciſes of the wit and invention of men.

Of this we might give divers inſtances: in mathematics, about ſquaring the circle[y]; in mechanics,

---

[v] Gen. iv. 22.

[w] Σφυροκόπος the LXX. call him, i. e. a worker with an hammer.

[x] Gen. iv. 21.

[y] Although the quadrature of the circle hath in former ages exerciſed ſome of the greateſt mathematical wits; yet nothing has been done

chanics[z], about the art of flying; and in navigation

---

done in that way ſo conſiderable, as in and ſince the middle of the laſt century; when in the year 1657, thoſe very ingenious and great men, Mr. William Neil, and my Lord Brounker, and Sir Chriſtopher Wren afterwards, in the ſame year, geometrically demonſtrated the equality of ſome curves to a ſtraight line. And not long afterwards, this was brought under an analytical calculus: the firſt ſpecimen whereof, that was ever publiſhed, Mr. Mercator gave in 1688, in a demonſtration of my Lord Brounker's quadrature of the hyperbola, by Dr. Wallis's reduction of a fraction, into an infinite ſeries by diviſion. But the penetrating genius of Sir Iſaac Newton had diſcovered a way of attaining the quantity of all quadrible curves analytically, by his method of fluxions, ſome time before the year 1688, as I find very probable from an hiſtorical account, in a long letter of Mr. Collins, written in his own hand, and ſent to Richard Townley, Eſq; of Lancaſhire, whoſe papers are in my hands. In that letter Mr. Collins ſaith, that 'in September 1668, Mr. Mercator 'publiſhed his Logarithmotechnica, one of which he ſoon ſent to Dr. 'Barrow, who thereupon ſent him up ſome papers of Mr. Newton's '[now Sir Iſaac;] by which, and former communications made 'thereof by the author, to the doctor, it appears, that the ſaid me'thod was invented ſome years before by the ſaid Mr. Newton, and 'generally applied.' And then he goes on to give ſome account of the method; what it performs in the circle, &c. what Mr. Gregory had done in that kind, 'who intended to publiſh ſomewhat in Latin 'about it, but would not anticipate Mr. Newton, the firſt inventor 'thereof;' with much more of this nature. The deſign, I find, of that indefatigable promoter of mathematics, Mr. Collins, was to acquaint Mr. Townley, in his letter, with what had been done; and to get the aſſiſtance of that ingenious gentleman, towards the compleating a body of algebra.

[z] I do not mention here the perpetual motion, which hath exerciſed the mechanical wits for many ages, becauſe it is a thing impoſſible, if not a contradiction: as the before commended Dr. Clarke aſſerts in Rohaul. Phyſ. p. 133.

gation, about finding the longitude. Theſe things, although ſome of them in appearance innocent, yea, perhaps very uſeful, yet remain for the moſt part ſecret; not becauſe the diſcovery of moſt of them is more impoſſible, or difficult than of many other things, which have met with a diſcovery; nor is it for want of man's diligence therein, or his careful purſuit and enquiry after them, (for perhaps, nothing already diſcovered hath been more eagerly ſought after;) but with much better reaſon (I am ſure with greater humility and modeſty) we may conclude it is, becauſe the infinitely wiſe Creator, and ruler of the world, hath been pleaſed to lock up theſe things from man's underſtanding and invention, for ſome reaſons beſt known to himſelf, or becauſe they might be of ill conſequence, and dangerous amongſt men,

As in all probability the art of flying would particularly be: an art which in ſome caſes might be of good uſe, as to the geographer and philoſopher; but in other reſpects, might prove of dangerous and fatal conſequence: as for inſtance, by putting it in man's power to diſcover the ſecrets of nations and families more than is conſiſtent with the peace of the world for men to know; by giving ill men greater opportunities to do miſchief, which it would not lie in the power of others to prevent; and, as one obſerves[a], by making men leſs ſociable: 'For upon 'every true or falſe ground of fear, or diſcon-'tent, and other occaſions, he would have been 'fluttering away to ſome other place; and man-'kind, inſtead of cohabiting in cities, would, 'like the eagle, have built their neſts upon 'rocks.'

That this is the true reaſon of theſe matters, is manifeſt enough from holy ſcripture; and reaſon [b] alſo gives its ſuffrage thereto. The ſcripture expreſly tells us, that 'every good gift, and 'every perfect gift, is from above, and cometh 'down from the Father of lights,' St. James i. 17. Solomon, Prov. ii. 6. ſaith, 'The Lord 'giveth wiſdom; out of his mouth cometh 'knowledge and underſtanding.' And Elihu is very expreſs, Job xxxii. 8. 'But there is a 'ſpirit in man, and the inſpiration of the Al-'mighty giveth them underſtanding; Πνοὴ παντοκράτορός ἐστιν ἡ διδάσκουσα, as the LXX render it, 'The 'inſpiration, the afflatus of the Almighty, is

---

[a] Grew's Coſmol. Sacr. l. 1. c. 5. ſect. 25.

[b] 'Nemo igitur vir magnus ſine aliquo afflatu divino unquam 'fuit.' Cic. de Nat. Deor. l. 2. c. 66.

‘ their inſtructor, miſtreſs, or teacher.’ And in ſcripture, not only the more noble, ſuperior acts of wiſdom or ſcience, but much inferior alſo, bear the name of wiſdom, knowledge, and underſtanding, and are aſcribed unto God. It is well known that Solomon's wiſdom is wholly aſcribed unto God; and the wiſdom and underſtanding which God is ſaid to have given him, 1 Kings iv. 29. is particularly ſet forth in the following verſes, by his great ſkill in moral and natural philoſophy, in poetry, and probably in aſtronomy, geometry, and ſuch other of the politer ſciences, for which Egypt, and the Eaſtern nations were celebrated of old[*]; ‘ And Solomon's wiſdom excelled the wiſdom of all the children of the Eaſt country, and all the wiſdom of Egypt. For he was wiſer than all men, than Ethan, &c. And he ſpake 3000 proverbs: and his ſongs were 1005. And he ſpake of trees, from the cedar to the hyſop of the wall, (i. e. of all ſorts of plants;) alſo of beaſts, fowl, creeping things, and fiſhes.’ So likewiſe the wiſdom of Daniel, and his three companions, is aſcribed unto God, Dan. i. 17. 'As for theſe four children, God gave them knowledge, and ſkill in 'all learning and wiſdom; and Daniel had un'derſtanding in all viſions and dreams.' And accordingly in the next chapter, Daniel acknowledgeth and praiſeth God, ver. 20, 21. 'Daniel 'anſwered and ſaid, Bleſſed be the name of God 'for ever and ever, for wiſdom and might are 'his.—He giveth wiſdom unto the wiſe, and 'knowledge to them that know underſtanding.' But not only ſkill in the ſuperior arts and ſciences, but even in the more inferior mechanic arts, is called by the ſame names, and aſcribed unto God: thus for the workmanſhip of the tabernacle, Exod. xxxi. 2. to ver. 6. 'See, I have 'called Bezaleel; and I have filled him with the 'Spirit of God, in wiſdom, and in underſtand'ing, and in all manner of workmanſhip: to 'deviſe cunning works, to work in gold, ſilver 'and braſs; and in cutting of ſtones, to ſet them, 'and in carving of timber, to work in all man'ner of workmanſhip.' So the ſpinſters, weavers and other crafts-people, are called wiſe-hearted, Exod. xxxiv. 10, 25. and other places. And in Exod. xxxvi. 1, &c. the Lord is ſaid to have put this wiſdom in them, and underſtanding to know how to work all theſe manner of works, for the ſervice of the ſanctuary. And laſtly, to name no more inſtances, Hiram the chief architect of Solomon's temple, is in 1 Kings vii. 14. and 2 Chron. ii. 14. called 'a cunning man, filled 'with wiſdom and underſtanding, to work in 'gold, ſilver, braſs, iron, ſtone, timber, purple, blue, fine linnen, and crimſon; alſo to 'grave, and find out every device which ſhould 'be put to him.'

---

[*] Egypt, and ſome of the Eaſtern nations, are celebrated for their ſkill in polite literature; both in ſcripture and profane ſtory: Job was of thoſe parts; ſo were the Σοφοὶ and Μάγοι, the Brachmans and Gymnoſophiſts. Moſes and Daniel had their education in theſe parts: and Pythagoras, Democritus, and others, travelled into theſe parts for the ſake of learning.

Thus doth the word of God aſcribe the contrivances and crafts of men, to the agency, or influence of the Spirit of God, upon that of man. And there is the ſame reaſon for the variety of genii, or inclinations of men alſo; which from the ſame ſcriptures may be concluded to be a deſignation, and tranſaction of the ſame almighty governor of the world's affairs. And who indeed, but HE, could make ſuch a divine ſubſtance, endowed with thoſe admirable faculties and powers, as the rational ſoul hath; a being to bear the great Creator's vicegerency in this lower world; to employ the ſeveral creatures; to make uſe of the various materials; to manage the grand buſineſs; and to ſurvey the glories of all the viſible works of God! A creature, without which this lower world would have been a dull, uncouth and deſolate kind of globe! Who, I ſay, or what leſs than the infinite God, could make ſuch a rational creature, ſuch a divine ſubſtance as the ſoul! For if we ſhould allow the Atheiſt any of his nonſenſical ſchemes, the Epicurean his fortuitous concourſe of atoms, or the Carteſian [d] his created matter put in motion; yet with what tolerable ſenſe could he, in his way, produce ſuch a divine, thinking, ſpeaking, contriving, ſubſtance as the ſoul is; endowed exactly with ſuch faculties, powers, and diſpoſitions as the various neceſſities and occaſions of the world require from ſuch a creature! Why ſhould not rather all the acts, the diſpoſitions and contrivances of ſuch a creature as man, if made in a mechanical way, and not contrived by God, have been the ſame? Particularly, why ſhould he not have hit upon all contrivances of equal uſe, early as well as many ages ſince? Why not that man have effected, as well as this, ſome thouſands of years after? Why alſo ſhould not all nations, and all ages[e], improve in every thing, as well as this, or

---

[d] As we are not to accuſe any falſly, ſo far be it from me to detract from ſo great a man as Monſieur Cartes was; whoſe principles, although many have perverted to atheiſtical purpoſes, and whoſe notions have, ſome of them, but an ill aſpect, yet I am unwilling to believe he was an Atheiſt; ſince in his Principia Philoſophiæ, and other of his works, he vindicates himſelf from this charge; and frequently ſhews ſeemingly a great reſpect for religion: beſides that, many of his ſuſpicious opinions are capable of a favourable interpretation, which will make them appear in a better form: thus when he diſcardeth final cauſes from his philoſophy, it is not a denial of them; but only excluding the conſideration of them, for the ſake of free philoſophiſing; it being the buſineſs of a divine, rather than a philoſopher, to treat of them.

---

[e] For ages of learning and ignorance, we may compare the preſent, and ſome of the ages before the reformation. The laſt century, and the few years of this, have had the happineſs to be able to vie with any age for the number of learned men of all profeſſions, and the improvement made in all arts and ſciences; too many, and too well known to need a ſpecification.

But for ignorance, we may take the ninth age, and ſo down to the reformation; even as low as Queen Elizabeth, although learning began to flouriſh; yet we may gueſs how matters ſtood, even among the clergy, by her 53. Injunct. An. 1559. 'Such as are 'but mean readers ſhould peruſe over before, once or twice, the 'chapters and homilies, to the intent they may read to the better 'underſtanding of the people, the more encouragement of godli'neſs.' Spar. Collect. p. 82. But this is nothing, in compariſon to the ages before, when a monk ſaid, 'Græcum non eſt legi;' or as Eſpencæus more elegantly hath it, 'Græce noſſe ſuſpectum, He'braice prope hæreticum.' Which ſuſpicion, ſaid the learned Hakewill, Rhemigius ſurely was not guilty of, in commenting upon *diffamatus*, 1. Theſ. i. 8. who ſaith, that St. Paul ſomewhat improperly put that for *divulgatus*, not being aware that St. Paul wrote in Greek, and not in Latin. Nay, ſo great was their ignorance, not only of Greek, but of Latin too, that a prieſt baptized 'in no'mine Patria, et Filia, Spiritua ſancta.' Another ſuing his pariſhioners for not paving his church, proved it from Jer. xvii. 18. 'Pa'veant illi, non paveam ego. Some divines in Eraſmus's time undertook to prove Heretics ought to be burnt, becauſe the apoſtle ſaid, 'Hæreticum devita.' Two friars diſputing about a plurality of worlds, one proved it from 'Annon decem ſunt facti mundi?' The other or that age, or nation only [f]? Why ſhould the Greeks, the Arabians, the Perſians, or the Egyptians of old, ſo far exceed thoſe of the ſame nations now? Why the Africans and Americans, ſo generally

---

other replied, ‘ Sed ubi ſunt novem?’ And notwithſtanding their ſervice was read in Latin, yet ſo little was that underſtood, that an old prieſt in Henry VIII. read *mumpſimus Domine* for *ſumpſimus*: and being admoniſhed of it, he ſaid, he had done ſo for thirty years, and would not leave his old *mumpſimus* for their new *ſumpſimus*.

[f] ‘ There is, it ſeems, in wits and arts, as in all things beſide, ‘ a kind of circular progreſs; they have their birth, their growth, ‘ their flouriſhing, their failing, their fading; and within a while ‘ after, their reſurrection, and reflouriſhing again. The arts ‘ flouriſhed for a long time among the Perſians, the Chaldaeans, the ‘ Egyptians—But afterwards the Græcians got the ſtart of them,’ ‘ and are now become as barbarous themſelves, as formerly they ‘ eſteemed all beſides themſelves to be.’ About the birth of Chriſt, learning began to flouriſh in Italy, and ſpread all over Chriſtendom till the Goths, Huns, and Vandals, ranſacked the libraries, and defaced almoſt all the monuments of antiquity: ſo that the lamp of learning ſeemed to be put out, for near the ſpace of 1000 years, till the firſt Manſor, king of Africa and Spain, raiſed up, and ſpurred forward the Arabian wits, by great rewards and encouragements. Afterwards Petrarch opened ſuch libraries as were undemoliſhed. He was ſeconded by Boccace, and John of Ravenna, and ſoon after by Aretine, Philelphus, Valla, etc. And thoſe were followed by Æneas Sylvius, Angelus Politianus, Hermolaus Barbarus, Marſilius, Ficinus, and Joh. Picus of Mirandula. Theſe were backed by Rud. Agricola, Reucline, Melancthon, Joach. Camerarius, Wolph, Lazius, Beat. Rhenanus, Almaines: by Eraſmus of Rotterdam; Vives, a Spaniard; Bembus, Sadoletus, Eugubinus. Italians: Turnebus, Muretus, Ramus, Pithaeus, Budeaus, Amiot, Scaliger,

rally ignorant and barbarous, and the Europeans, for the moſt part, polite and cultivated, addicted to arts and learning? How could it come to paſs, that the uſe of the magnet[g], printing[h], clocks[i], teleſcopes

---

Scaliger, Frenchmen: Sir Tho. More, and Linaker, Engliſhmen. and about this time, even thoſe northern nations yielded their great men: Denmark yielded Olaus Magnus, Holſter, Tycho Brahe, and Hemingius; and Poland, Hoſtus, Frixius, and Crumerus. But to name the worthies that followed theſe, down to the preſent time would be endleſs, and next to impoſſible. See therefore Hakewill's Apol. l. 3. c. 6. ſect. 2.

[g] Dr. Gilbert, the moſt learned and accurate writer on the magnet, ſhews, that its attractive virtue was known as early as Plato and Ariſtotle; but its direction was a diſcovery of later ages. He ſaith, 'Superiori aevo 300 aut 400 labentibus annis, motus, magneticus 'in Boream et Auſtrum repertus, aut ab hominibus rurſus recognitus 'fuit.' De Mag. l. 1. c. 1. But who the happy inventor of this lucky diſcovery was, is not known. There is ſome, not inconſiderable, reaſon to think, our famous countryman, Rog. Bacon, either diſcovered, or at leaſt knew of it. But for its uſe in navigation, Dr. Gilbert ſaith, 'In regno Neapolitano Melphitani omnium primi, 'uti ferunt, pyxidem inſtruebant nauticam—edocti a cive quodam, 'Jol. Gohia, A. D. 1300. ibid.' If the reader hath a mind to ſee the arguments for the invention being as old Solomon's or Plautus's time, or of much younger date, he may conſult Hakewill, ib. c. 10. ſect. 4. or Purchas Pilgr. l. 1. c. 1. ſect. 1.

As to the magnetic variation, Dr. Gilbert attributes the diſcovery of it to Sebaſtian Cabott. And the inclination, or dipping of the needle, was the diſcovery of our ingenious Rob. Norman. And laſtly, the variation of the variation was firſt found out by the ingenious Mr. H. Gellibrand, Aſtr. Prof. of Greſh. Coll. about 1634. Vide Gellibr. Diſc. Math. on the Variation of the Mag. Needle and its Variat. anno 1635.

But ſince that, the before commended Dr. Halley, having formerly, in Phil. Tranſ. No 148, and 195, given a probable hypotheſis of the variation of the compaſs, did, in the year 1700, undertake a long and hazardous voyage, as far as the ice near the ſouth pole, in order to examine his ſaid hypotheſis, and to make a ſyſtem of the magnetical variations: which being ſoon after publiſhed, has been ſince abundantly confirmed by the French, as may be ſeen in ſeveral of the late Memoires de Phyſique et de Mathematique, publiſhed by the French Academie des Sciences.

To theſe diſcoveries, I hope the reader will excuſe me, if I had one of my own, which I deduced ſome years ago, from ſome magnetical experiments and obſervations I made; which diſcovery I alſo acquainted our Royal Society with, ſome time ſince, viz. that as the common, horizontal needle is continually varying up and down, towards the E. and W. ſo is the dipping needle varying up and down, towards and fromwards the zenith, with its magnetic tendency, deſcribing a circle round the pole of the world, as I conceive, or ſome other point. So that if we could procure a needle ſo nicely made, as to point exactly according to its magnetic direction, it would, in ſome certain number of years, deſcribe a circle of about 13 gr. radius round the magnetic poles northerly and ſoutherly. This I have for ſeveral years ſuſpected, and have had ſome reaſon for it too, which I mentioned three or four years ago, at a meeting of our Royal Society; but I have not yet been ſo happy to procure a tolerable good dipping needle, or other proper one to my mind, to bring the thing to a ſufficient teſt of experience, as in a ſhort time I hope to do, having lately hit upon a contrivance that may do the thing.

[b] It is uncertain who was the inventor of the art of printing, every hiſtorian aſcribing the honour thereof to his own city or country, Accordingly ſome aſcribe the invention of it to John Guttenburg, a knight of Argentine, about 1440, and ſay that Fauſtus was only his aſſiſtant. Bertius aſcribes it to Laurence John, of Haerlem, and ſaith, Fuſt or Fauſt, ſtole from him both his art and tools. And, to name no more, ſome attribute it to John Fuſt or Fauſt, and Peter

teleſcopes[k], and an hundred things beſides, ſhould eſcape the diſcovery of Archimedes, Anaximander, Anaximenes, Poſſidonius, or other great virtuoſos of the early ages, whoſe contrivances of various engines, ſpheres clepſydrae, and other curious inſtruments,

---

Schoeffer (called by Fuſt, in ſome of his imprimaturs, Pet. de Gerneſhem puer meus.) But there is now to be ſeen at Haerlem, a book or two printed by Lau. Koſter, before any of theſe, viz. in 1430 and in 1432. (See Mr. Ellis's Letter to Dr. Tyſon, in Phil. Tranſ. No. 286.) But be the firſt inventor who it will, there is however great reaſon to believe the art received great improvements from Fauſt, and his ſon-in-law Schoeffer, the latter being the inventer of metalline types, which were cut in wood before, firſt in whole blocks, and afterwards in ſingle types or letters. See my learned friend Mr. Wanley's obſervations, in Phil Tranſ. No. 288, and 310.

[l] Concerning the antiquity and invention of clocks and clock-work, I refer the reader to a little book, called, The Artificial Clock-maker, chap. 6. where there is ſome account of the antients inventions in clock-work, as Archimedes's ſphere, Cteſibius's clock, &c.

[k] The invention of Teleſcopes, Hieron. Syrturus gives this account of. 'Prodiit Anno 1609, ſeu genius, ſeu alter vir adhuc incognitus, Hollandi ſpecie, qui Middleburgi in Zelandia convenit Joh. Lipperſein——Juſſit perſpicilla plura tam cava quam convexa, confici Condicto die rediit, abſolutum opus capiens, atque ut ſtatim habuit præ manibus, bina ſuſcipiens, cavum ſcil. et convexum, unum et alterum oculo admovebat, et ſenſim dimovebat, ſive ut punctum concurſus, ſive ut artificis opus probaret, poſtea abiit. Artifex, ingenii minime expers, et novitatis curioſus cœpit idem facere et imitari,' &c. V. Muſ. Wor. l. 4. c. 7.

inſtruments, are recorded [1]? And why cannot the preſent

---

[1] Among the curious inventions of the antients, Archytas's dove was much famed; of which Aul. Gellius gives this account: 'Scrip-'ſerunt ſimulachrum columbæ e ligno ab Archyta ratione quadam 'diſciplinaque mechanica factum, volaſſe: ita erat ſcilicet libra-'mentis ſuſpenſum, et aura ſpiritus incluſa atque occulta concitum.' Noct. Attic. l. 20. c. 12. The ſame eminent Pythagorean philoſopher, as Favorinus in Gellius calls him, is by Horace accounted a noble geometrician too, 'Te maris et terræ, numeroque carentis 'arenæ Menſorem Archyta.' Among the reſt of his inventions, childrens rattles are aſcribed to him. Ariſtotle calls them, Ἀρχύτȣ πλαταγὴ, Polit. 1. i. e. Archytas's rattle. And Diogenianus, the grammarian, gives the reaſon of his invention, Ἀρχύτȣ πλαταγὴ ἐπὶ τῶν, &c. 'That Archytas's rattle was to quiet children; for he 'having children, contrived the rattle, which he gave them to pre-'vent their tumbling [διασκαλεύωσι,] other things about the houſe.'

To theſe contrivances of Archytas, we may add Regiomontanus's wooden eagle, 'which flew forth of the city, aloft in the air, met 'the emperor a good way off, coming towards it, and having ſaluted 'him returned again, waiting on him to the city gates.' Alſo his iron fly, which at a feaſt, 'flew forth of his hands, and taking a round, returned thither again.' Vide Hakewill, ubi ſupra, c. 10. ſect. 1.

As to other inventions of the ancients, ſuch as of letters, bricks, and tiles, and building houſes, with the ſaw, rule, and plumber, the lath, augre, glue, &c. alſo the making braſs, gold, and other metals, the uſe of ſhields, ſwords, bows, and arrows, boots, and other inſtruments of war; the pipe, harp, and other muſical inſtruments; the building of ſhips, and navigation, and many other things beſides; the inventors of theſe, as reported by antient heathen authors, may be plentifully met with in Pliny, Nat. Hiſt. l. 7. c. 56.

But in this account of Pliny, we may obſerve whence the ancients, even the Romans themſelves in ſome meaſure, had their accounts of theſe preſent or paſt age, ſo eminent for polite literature, for diſcoveries and improvements in all curious arts and buſineſſes (perhaps beyond any known age of the world; why cannot it, I ſay) diſcover thoſe hidden Quaeſita, which may probably be reſerved for the diſcovery of future and leſs learned generations?

Of theſe matters, no ſatisfactory account can be given by any mechanical hypotheſis, or any other way, without taking in the ſuperintendence

---

theſe matters, viz. from the fabulous Greeks, who where fond of aſcribing every thing to themſelves. 'The truth is (ſaith the moſt learned Biſhop Stillingfleet) there is nothing in the world uſeful or beneficial to mankind, but they have made a ſhift to find the author of it among themſelves. If we enquire after the original of agriculture, we are told of Ceres and Triptolemus; if of paſturage, we are told of an Arcadian Pan; if of wine, we preſently hear of a Liber Pater; if of iron inſtruments, then who but Vulcan; if of muſic, none like to Apollo. If we preſs them then with the hiſtory of other nations, they are as well provided here; if we enquire an account of Europe, Aſia, or Libya; for the firſt, we are told a fine ſtory of Cadmus's ſiſter; for the ſecond, of Prometheus's mother of that name; for the third, of a daughter of Epaphus.' And ſo the learned author goes on with other particular nations, which they boaſted themſelves to be the founders of. 'Only the grave Athenians thought ſcorn to have any father aſſigned them, their only ambition was to be accounted "aborigines et genuini terræ." But the ignorance and vanity of the Greek hiſtory, that learned author hath ſufficiently refuted. Vide Stillingfleet's Orig. Sacr. part 1 book 1. chap. 4.

ence of the great Creator and ruler of the world, who oftentimes doth manifeſt himſelf in ſome of the moſt conſiderable of thoſe works of men, by ſome remarkable tranſactions of his providence; or by ſome great revolution or other happening in the world thereupon. Of this I might inſtance in the invention of printing[m], ſucceeded firſt by a train of learned men, and the revival of learning, and ſoon after that by the reformation, and the much greater improvements of learning at this day. But the moſt conſiderable inſtance I can give is, the progreſs of Chriſtianity, by means of the civilized diſpoſition, and large extent of the Roman empire. The latter of which as it made way for human power, ſo the former made way for our moſt excellent religion into the minds of men. And ſo I hope, and earneſtly pray, that the omnipotent and all-wiſe ruler of the world will tranſact the affairs of our moſt holy religion, ere it be long, in the heathen world; that the great improvement made in the laſt, and preſent age, in arts and ſciences, in navigation and commerce, may be a means to tranſport our religion, as well as name, through all the nations of the earth. For we find that our culture of the more polite and curious ſciences, and our great improvements in even the mechanic arts, have already made a way for us into ſome of the largeſt and fartheſt diſtant nations of the earth; particularly into the great empire of China[n].

---

[m] Whether printing was invented in 1440, as many imagine, or was ſooner practiſed, in 1430, or 1432, as Mr. Ellis's account of the Dutch inſcription, in Phil. Tranſ. No. 286 doth import; it is however manifeſt, how great an influence, as it was natural, this invention had in the promoting of learning ſoon afterwards, mentioned before in note (h) p. 389. After which followed the reformation, about the year 1517.

And now, before I quit this ſubject, I cannot but make one remark, by way of practical inference, from what has been laſt ſaid; and that is, ſince it appears, that the ſouls of men are ordered, diſpoſed, and actuated by God, even in ſecular, as well as ſpiritual Chriſtian acts, a duty ariſeth thence on every man, to purſue the ends, and anſwer all the deſigns of the divine providence, in beſtowing his gifts and graces upon him. Men are ready to imagine their wit, learning, genius, riches, authority, and ſuch like, to be works of nature, things of courſe, or owing to their own diligence, ſubtility, or ſome ſecondary cauſes; that they are maſters of them and at liberty to uſe them as they pleaſe, to gratify their luſt or humour, and ſatisfy their depraved appetites. But it is evident, that theſe things are the gifts of God; they are ſo many talents entruſted with us by the infinite Lord of the world, a ſtewardſhip, a truſt repoſed in us; for which we muſt give an account at the day when our Lord ſhall call; according to the parabolical repreſentation of this matter by our bleſſed Saviour, Matt. xxv. 14.

---

[n] The Chineſe being much addicted to judicial aſtrology, are great obſervers of the heavens, and the appearances in them. For which purpoſe they have an obſervatory at Pekin, and five mathematicians appointed to watch every night: four towards the four quarters of the world, and one towards the zenith, that nothing may eſcape their obſervation; which obſervations are the next morning brought to an office to be regiſtered. But notwithſtanding this their diligence for many ages, and that the emperor hath kept in his ſervice above 100 perſons, to regulate the kalendar, yet are they ſuch mean aſtronomers, that they owe the regulation of their kalendar, the exactneſs in calculating eclipſes, &c. to the Europeans; which renders the European mathematicians ſo acceptable to the emperor, that father Verbieſt, and divers others, were not only made principals in the obſervatory, but put into places of great truſt in the empire, and had the greateſt honors paid them at their deaths. Vide La Compte Mem. of China, Letter 2, &c.

Our duty then is not to abuſe theſe gifts of God, ‘not to neglect the gift that is in us, not ‘ to hide our talent in the earth;’ but, as St. Paul exhorteth Timothy, 2 Tim. i. 6, we muſt ‘ ſtir up the gift of God which is in us,’ and not let it lie idle, concealed, or dead; but we muſt ἀναζωπυρεῖν τὸ χάρισμα, ‘ blow it up, and enkindle it,’ as the original imports; we muſt improve and employ our gift to the glory of the giver: or, in that miniſtration, that uſe and ſervice of the world, for which he gave it. Our ſtewardſhip, our craft, our calling, be it that of embaſſadors of heaven, committed to us, as it was to Timothy [o], by the laying on of hands; or be it the more ſecular buſineſs of the gentlemen, tradeſman, mechanic, or only ſervant; nay, our good genius, our propenſity to any good, as ſuppoſe to hiſtory, mathematics, botany, natural philoſophy, mechanics, &c. I ſay, all theſe occupations, in which the providence of God hath engaged men, all the inclinations to which his Spirit hath diſpoſed them, ought to be diſcharged with that diligence, that care and fidelity, that our great Lord and maſter may not ſay to us, as was ſaid to the unfaithful ſteward, Luke xvi. 2. 'Give an account of thy ſtewardſhip, for 'thou mayeſt be no longer ſteward;' but that he may ſay, as it is in the parable before cited, Matth. xxv. 21. 'Well done thou good and 'faithful ſervant, thou haſt been faithful over 'a few things, I will make thee ruler over many 'things, enter thou into the joy of thy Lord.' Since now the caſe is thus, let us be perſuaded to follow Solomon's advice, Eccl. ix. 10. 'Whatſoever thy hand findeth to do, do it with thy

---

[o] 1 Tim. iv. 14. 2 Tim. i. 6.

‘ might’[p], ‘ Lay hold on every occaſion that
‘ preſents itſelf, and improve it with the utmoſt
‘ diligence; becauſe now is the time of action,
‘ both in the employments of the body and of
‘ the mind; now is the ſeaſon of ſtudying either
‘ arts and ſciences, or wiſdom and virtue, for
‘ which thou wilt have no opportunities in the
‘ place whither thou art going in the other
‘ world. For there is no work, nor device, nor
‘ knowledge, nor wiſdom in the grave whither
‘ thou goeſt.

---

[p] Biſhop Patrick in loc.

CHAP. II.

OF MAN'S BODY, PARTICULARLY ITS POSTURE.

HAVING thus, as briefly as I well could, ſurveyed the Soul, let us next take a view of Man's Body. Now, here we have ſuch a multiplicity of the moſt exquiſite workmanſhip, and of the beſt contrivance, that if we ſhould ſtrictly ſurvey the body from head to foot, and ſearch only into the known parts, and many more that lie undiſcovered, we ſhould find it too large and tedious a taſk to be diſpatched. I ſhall therefore have time only to take a tranſient and general kind of view of this admirable machine, and that ſomewhat briefly too, being prevented by others, particularly two excellent authors of our own[q], who have done it on the ſame account as myſelf. And the

---

[q] Mr. Ray, in his Wiſdom of God manifeſted in the Works of Creation, part 2. And Dr. Cockburn's Eſſays on Faith, part 1. Eſſay 5.

I. Thing that preſents itſelf to our view, is the erect poſture[r] of man's body; which is far the moſt, if not the only commodious poſture for a rational creature, for him that hath dominion over the other creatures, for one that can invent uſeful things, and practiſe curious arts. For, without this erect poſture, he could not have readily turned himſelf to every buſineſs, and on every occaſion. His hand[s] particularly could not have

---

[r] ‘Ad hanc providentiam naturæ tam diligentem [of which he had been before ſpeaking] tamque ſolertem adjungi multa poſſunt, a quibus intelligatur, quantæ res hominibus a Deo, quamque eximiæ tributæ ſunt: qui primum eos humo excitatos, celſos et erectos conſtituit, ut deorum cognitionem cœlum intuentes, capere poſſent. Sunt enim e terra homines non ut incolæ, atque habitatores, ſed quaſi ſpectatores ſuperarum rerum, atque cœleſtium, quarum ſpectaculum ad nullum aliud genus animantium pertinet.' Cic de Nat. Deor. l. 2. c. 56.

[s] ‘Ut autem ſapientiſſimum animalium eſt homo, ſic et manus ſunt organa ſapienti animali convenientia. Non enim qui manus habuit, propterea eſt ſapientiſſimum, ut Anaxagoras dicebat; ſed quia ſapientiſſimum erat, propter hoc manus habuit, ut rectiſſime cenſuit Ariſtoteles. Non enim manus ipſæ hominem artes docuerunt, ſed ratio. Manus autem ipſæ ſunt artium organum,' &c. Galen de uſu Part. l. 1. c. 3. After which, in the reſt of his firſt book, and part of the ſecond, he conſiders the particulars of the hand, in order to enquire, as he ſaith, ch. 5. ‘Num eam omnino conſtitutionem habeat [manus] qua meliorem aliam habere non potuit.'

‘Of this part, and indeed of the other parts of human bodies, he gives ſo good an account, that I confeſs I could not but admire the ſkill have been in ſo great a readineſs to execute the commands of the will, and dictates of the ſoul. His eyes would have been the moſt prone, and incommodiouſly ſituated of all animals; but by this ſituation, he can caſt his eyes upwards, downwards, and round about him; he hath a glorious hemiſphere of the heavens [t] and an ample horizon on earth [u], to entertain his eye.

And

ſkill of that ingenious and famed heathen. For an example, becauſe it is a little out of the way, I ſhall pitch upon his account of the different lengths of the fingers, lib. 1. c. 24. The reaſon of this mechaniſm, he ſaith, is, that the tops of the fingers may come to an equality, 'Cum magnas aliquas moles in circuitu comprehendunt, 'et cum in ſeipſis humidum vel parvum corpus continere conantur.— 'Apparent vero in unam circuli circumferentiam convenire digiti 'quinque in actionibus hujuſmodi, maxime quando exquiſite ſphæ'ricum corpus comprehendunt.' And this evenneſs of the fingers ends, in graſping ſpherical, and other round bodies, he truly enough ſaith, makes the hold firmer. And it ſeems a noble and pious deſign he had in ſo ſtrictly ſurveying the parts of man's body, which take in his own tranſlated words, 'Cum multa namque eſſet apud 'veteres, tam medicos, quam philoſophos de utilitate particularum 'diſſenſio (quidam enim corpora noſtra nullius gratia eſſe facta eſti'mant, nullaque omninó arte; alii autem et alicujus gratia, et arti'ficioſe,—) primum quidem tantæ hujus diſſenſionis κριτήριον inve'nire ſtudui: deinde vero et unam aliquam univerſalem methodum 'conſtituere, qua ſingularem partium corporis, et eorum quæ illis 'accidunt utilitatem invenire poſſemus.' Ibid. cap. 8.

[t] Pronaque cum ſpectant animalia cætera terram,
Os homini ſublime dedit, cœlumque tueri
Juſſit, et erectos ad ſidera tollere vultus.
Ovid. Metam. l. 1. car. 84.

[u] If any ſhould be ſo curious, to deſire to know how far a man's proſpect reacheth, by means of the height of his eye, ſuppoſing the

earth was an uninterrupted globe; the method is a common caſe of right angled plain triangles, where two ſides, and an oppoſite angle are given: thus in Fig. 4. A H B is the ſurface, or a great circle of the terraqueous globe; C the center, H C its ſemidiameter, E the height of the eye; and foraſmuch as H E is a tangent, therefore the angle at H is a right angle; ſo that there are given H C 398,386 miles, or 21,034,781 Engliſh feet, according to book ii. chap. 2. note (z) p. 58 C E the ſame length with the height of the eye, on the maſt of a ſhip, or at only a man's height, &c. added to it; and E H C the oppoſite right angle. By which three parts given, it is eaſy to find all the other parts of the triangle. And firſt, the angle at C. in order to find the ſide H E, the proportion is, as the ſide C E, to the angle at H; ſo the ſide H C, to the angle at E, which being ſubſtracted out of 90 gr. the remainder is the angle at C. And then as the angle at E is to its oppoſite ſide H C, or elſe as the angle at H is to its oppoſite ſide C E; ſo the angle at C, to its oppoſite ſide E H, the viſible horizon. Or the labour may be ſhortened, by adding together the logarithm of the ſum of the two given ſides, and the logarithm of their difference; the half of which two logarithms is the logarithm of the ſide required, nearly. For an example, we will take the two ſides in yards; by reaſon ſcarce any table of logarithms will ſerve us farther. The ſemidiameter of the earth is 7,011,594 yards; the height of the eye is two yards more, the ſum of both ſides is, 14,023,190.

Logar. of which ſum is, - -	7,1468468
Logar. of two yards (the difference) is, -	0,3010300
Sum of both Logar. - - -	7,4478768
The half ſum, - - -	3,7239384

is the logarithm of 5296 yards = three miles, which is the length of the line E H, or diſtance the eye can reach at ſix feet height.

This would be the diſtance, on a perfect globe, did the viſual rays come to the eye in a ſtrait-line; but by means of the refractions of the atmoſphere, diſtant objects on the horizon appear higher than really they are, and may be ſeen at a greater diſtance, eſpecially on the ſea; which is a matter of great uſe, eſpecially to diſcover at ſea

And as this erection of man's body is the moſt complete poſture for him; ſo if we ſurvey the proviſion made for it, we find all done with manifeſt deſign, the utmoſt art and ſkill being employed therein. To paſs by the particular confirmation of many of the parts, the ligaments and faſtenings to anſwer this poſture; as the faſtenings, for inſtance, of the pericardium to the diaphragm, (which is peculiar to man; [u] I ſay, paſſing by a deal of this nature, manifeſting this poſture to be an act of deſign) let us ſtop a little at the curious fabric of the bones, thoſe pillars of the body. And how artificially do we find them made, how curiouſly placed from the head to the foot! The vertebræ of the neck and backbone [w], made ſhort and complanated, and firmly braced with muſcles and tendons, for eaſy incurvations of the body; but withal for greater ſtrength

---

the land, rocks, &c. and it is a great act of the divine providence, in the contrivance and convenience of the atmoſphere, which by this means enlargeth the viſible horizon, and is all one, as if the terraqueous globe was much larger than really it is. As to the height of the apparent above the true level; or, how much diſtant objects are raiſed by the refractions, the ingenious and accurate gentlemen of the French Academy Royal have given us a table in their Meaſures of the earth, Art. 12.

[u] See book vi. chap. 5.

[w] See book iv. chap. 8.

ſtrength, to ſupport the body's own weight, together with other additional weights it may have occaſion to bear. The thigh-bones and legs long and ſtrong, and every way well fitted for the motion of the body. The feet accomodated with a great number of bones, curiouſly and firmly tacked together; to which muſt be added the miniſtry of the muſcles[x], to anſwer all the motions of the legs and thighs, and at the ſame time to keep the body upright, and prevent its falling, by readily aſſiſting againſt every vacillation

---

[x] The mechaniſm of the foot would appear to be wonderful, if I ſhould deſcend to a deſcription of all its parts; but that would be too long for theſe notes; therefore a brief account, (moſt of which I owe to the before-commended Mr. Cheſelden,) may ſerve for a ſample: in the firſt place, it is neceſſary the foot ſhould be concave, to enable us to ſtand firm, and that the nerves and blood-veſſels may be free from compreſſion, when we ſtand or walk. In order thereunto, the long flexors of the toes croſs one another at the bottom of the foot, in the form of a St. Andrew's croſs, to incline the leſſer toes towards the great one, and the great one towards the leſſer. The ſhort flexors are chiefly concerned in drawing the toes towards the heel. The tranſverſalis pedis draws the outſides of the foot towards each other; and by being inſerted into one of the ſeſamoid bones of the great toe, diverts the power of the abductor muſcle, falſly ſo called, and makes it become a flexor. And laſtly, the peronaeus longus runs round the outer ankle, end obliquely forwards croſs the bottom of the foot, and at once helps to extend the tarſus, to conſtrict the foot, and to direct the power of the other extenſors towards the ball of the great toe: hence the loſs of the great toe is more than of all the other toes. See alſo Mr. Cowper's Anat. tab. 28, &c.

tion thereof, and with eaſy and ready touches keeping the line of innexion and centre of gravity, in due place and poſture [y].

And as the bones are admirably adapted to prop, ſo all the parts of the body are as incomparably placed to poiſe it. Not one ſide too heavy for the other; but all in nice aequipoiſe: the ſhoulders, arms, and ſide aequilibrated on one part; on the other part of the viſcera of the belly counterpoiſed with the weight of the ſcapular part, and that uſeful cuſhion of fleſh behind.

And laſtly, to all this we may add the wonderful concurrence, and miniſtry, of the prodigious number and variety of muſcles, placed throughout the body for this ſervice; that they ſhould ſo readily anſwer to every poſture, and comply with every motion thereof, without any previous thought or reflex act, ſo that, as the excellent Borelli ſaith [z], 'It is worthy of admir-

---

[y] It is very well worth while to compare here what Borelli ſaith, de motu Animal; part 1. cap. 18. De ſtatione Animal. prop. 142, &c. To which I refer the reader, it being too long to recite here.

[z] Borel. ibid. prop. 142.

'ation, that in ſo great a variety of motions, as
'running, leaping, and dancing, nature's laws
'of aequilibration ſhould always be obſerved;
'and when neglected, or wilfully tranſgreſſed,
'that the body muſt neceſſarily and immediately
'tumble down.'

CHAP. III.

OF THE FIGURE AND SHAPE OF MAN'S BODY.

THE figure and ſhape of man's body, is the moſt commodious that could poſſibly be invented for ſuch an animal; the moſt agreeable to his motion, to his labours, and all his occaſions. For had he been a rational reptile, he could not have moved from place to place faſt enough for his buſineſs, nor indeed have done any almoſt. Had he been a rational quadrupede, among other things, he had loſt the benefit of his hands, thoſe noble inſtruments of the moſt uſeful performances of the body. Had he been made a bird, beſides many other great inconveniencies, thoſe before-mentioned of his flying would have been ſome. In a word, any other ſhape of body, but that which the all wiſe Creator hath given man, would have been as incommodious, as any poſture but that of erect; it would have rendered him more helpleſs, or have put it in his power to have been more pernicious, or deprived him of ten-thouſand benefits, or pleaſures, or conveniencies, which his preſent figure capacitates him for.

CHAP. IV.

OF THE STATURE AND SIZE OF MAN'S BODY.

AS in the figure, ſo in the ſtature and ſize of man's body, we have another manifeſt indication of excellent deſign. Not too pygmean [a], nor too gigantic [b], either of which ſizes would, in ſome particular or other, have been incommodious to himſelf, or to his buſineſs, or to the reſt of his fellow-creatures. Too pygmean would have rendered him too puny a lord of the creation; too impotent, and unfit to manage the inferior creatures; would have expoſed him to the aſſaults of voracious birds, and have put him in the way, and endangered his being trodden in the dirt by the larger animals. He would have been alſo too weak for his buſineſs, unable to carry burdens; and, in a word, to tranſact the greater part of his labours and concerns.

---

[a] What is here urged about the ſize of man's body, may anſwer one of Lucretius's reaſons, why 'nil ex nihilo gignitur.' His argument is,

> Denique cur homines tantos natura parare
> Non potuit, pedibus qui pontum per vada poſſent
> Tranſire, et magnos manibus divellere monteis?
>
> Lucret. l. 1. carm. 200.

[b] 'Haud facile fit ut quiſquam et ingentes corporis vires, et ingenium ſubtile habeat.' Diodor. Sic. l. 17.

And on the other hand, had man's body been made too monſtrouſly ſtrong, too enormouſly gigantic [c], it would have rendered him a danger-

ous

---

[c] Although we read of giants before Noah's flood, Gen. vi. 4. and more plainly afterwards in Numb. xiii. 33. yet there is great reaſon to think the ſize of man was always the ſame from the creation. for as to the Nephilim, or giants, in Gen. vi, the ancients vary about them; ſome taking them for great atheiſts, and monſters of impiety, rapine, tyranny, and all wickedneſs, as well as of monſtrous ſtature, according as indeed the Hebrew ſignifications allows.

And as for the Nephilim, in Num. xiii. which were evidently men of a gigantic ſize, it muſt be conſidered, that it is very probable, the fears and diſcontentments of the ſpies might add ſomewhat thereunto.

But be the matter as it will, it is very manifeſt, that in both theſe places, giants are ſpoken of as rarities and wonders of the age, not of common ſtature. And ſuch inſtances we have had in all ages; excepting ſome fabulous relations; ſuch as I take to be that of Theutobocchus, who is ſaid to have been dug up, Anno 1613, and to have been higher than the trophies, and 26 feet long; and no better I ſuppoſe the giants to have been that Ol. Magnus gives an account of, in his 5th book, ſuch as Harthen and Starchater, among the men, and among the women, 'Reperta eſt (ſaith he) puella—

'in capite vulnerata, ac mortua, induta chlamyde purpurea, longitudinis cubitorum 50, latitudinis inter humeros quatuor.' Ol. Mag. Hiſt. l. 5. c. 2.

But as for the more credible relations of Goliah, ('whoſe height was ſix cubits and a ſpan,' 1 Sam. xvii. 4. which, according to the late curious and learned Lord Bp. of Peterborough, is ſomewhat above 11 feet Engliſh; vid. Bp. Cumberland of Jewiſh weights and meaſures:) of Maximinus the emperor, who was 9 feet high, and others in Auguſtus, and other reigns, of about the ſame height; to which we may add, the dimenſions of a ſkeleton, dug up lately in the place of a Roman camp near St, Albans, by an urn, inſcribed Marcus Antoninus; of which an account is given by Mr. Cheſelden, who judgeth by the dimenſions of the bones, that the perſon was 8 feet high. Vide Phil. Tranſ. No. 333. Theſe antique examples and relations, I ſay, we can match, yea, out-do, with modern examples; of which we have divers in J. Ludolph. Comment. in Hiſt. Æthiop. l. 1. c. 2. ſect. 22. Magus, Conringius, Dr. Hakewill, and others. Which latter relates from Nannez, of porters and archers belonging to the emperor of China, of 15 feet high; and others from Purchas, of 10 and 12 feet high, and more, See the learned author's Apolog. p. 208.

Theſe indeed exceed what I have ſeen in England: but in 1684, I myſelf meaſured an Iriſh youth, ſaid to be not 19 years old, who was 7 feet and near 8 inches; and in 1697, a woman who was 7 feet 3 inches in height.

But for the ordinary ſize of mankind, in all probability, it was always, as I ſaid, the ſame, as may appear from the monuments, mummies, and other ancient evidences to be ſeen at this day. The moſt antient monument at this day, I preſume, is that of the Cheops, in the firſt and faireſt pyramid of Egypt; which was, no doubt, made of capacity every way ſufficient to hold the body of ſo great a perſon as was intended to be laid up in it: but this we find, by the nice meaſures of our curious Mr. Greaves, hardly to exceed our common coffins. 'The hollow part within, ſaith he, is in length ous tyrant in the world, too ſtrong[d], in ſome

reſpects,

‘ only 6,488 feet, and in breadth but 2,218 feet: the depth 2,860
‘ feet. A narrow ſpace, yet large enough to contain a moſt potent
‘ and dreadful monarch, being dead; to whom living all Egypt
‘ was too ſtraight and narrow a circuit. By theſe dimenſions, and
‘ by ſuch other obſervations, as have been taken by me from ſeveral
‘ embalmed bodies in Egypt, we may conclude there is no decay in
‘ nature, (though the queſtion is as old as Homer;) but that the
‘ men of this age are of the ſame ſtature they were near 3000 years
‘ ago.” Vide Greaves of the Pyram. in 1638, in Ray's Collect. of Trav. tom. 1. p. 118.

To this more antient, we may add others of a later date. Of which take theſe, among others, from the curious and learned Hakewill. The tombs at Piſa, that are ſome thouſand years old, are not longer than ours; ſo is Athelſtane's in Malmeſbury church; ſo Sebba's in St. Paul's, of the year 693; ſo Etheldred's, &c. Apol. 216, &c.

The ſame evidence we have alſo from the armour, ſhields, veſſels, and other utenſils dug up at this day. The braſs helmet dug up at Metaurum, which was not doubted to have been left there at the overthrow of Aſdrubal, will fit one of our men at this day.

Nay, beſides all this, probably we have ſome more certain evidence. Auguſtus was 5 feet 9 inches high, which was the juſt meaſure of our famous queen Elizabeth, who exceeded his height 2 inches, if proper allowance be made for the difference between the Roman and our foot. Vide Hakew. ib. p. 215.

[d] To the ſtature of men in the foregoing note, we may add ſome remarks about their unuſual ſtrength. That of Sampſon (who is not ſaid to have exceeded other men in ſtature, as he did in ſtrength) is well known. So of old, Hector, Diomedes, Hercules, and Ajax

are

reſpects, even for his own kind, as well as the other creatures. Locks and doors might perhaps

---

are famed; and ſince them many others; for which I ſhall ſeek no farther than the before-commended Hakewill, who, by his great and curious learning, hath often moſt of the examples that are to be met with, on all his ſubjects he undertakes. Of the after ages he names C. Marius, Maximinus, Aurelian, Scanderbeg, Bardeſin, Tamerlane, Ziſka, and Hunniades. Anno 1529, Klunher, provoſt of the great church at Miſnia, carried a pipe of wine out of the cellar, and laid it in the cart. Mayolus ſaw one hold a marble pillar in his hand 3 feet long, and 1 foot diameter, which he toſſed up in the air, and catched again as if it were a ball. Another at Mantua, and a little man named Rodamas, could break a cable, &c. Ernando Burg fetched up ſtairs an aſs loaden with wood, and threw both into the fire. At Conſtantinople, An. 1582, one lifted a piece of wood, that twelve men could ſcarce raiſe; then lying along, he bare a ſtone that ten men could but juſt roll to him. G. of Fronſberg, baron of Mindlehaim, could raiſe a man off his ſeat, with only his middle finger; ſtop a horſe in his full career; and ſhove a cannon out of its place. Cardan ſaw a man dance with two men in his arms, two on his ſhoulders, and one on his neck. Patacoua, captain of the Coſſacks, could tear an horſe-ſhoe; (and, if I miſtake not, the ſame is reported of the late king Auguſtus of Poland.) A gigantic woman of the Netherlands could lift a barrel of Hamburg beer. Mr. Carew had a tenant that could carry a butt's length, 6 buſhels of wheaten meal (of 15 gallons meaſure) with the lubber the miller, of 24 years of age, on the top of it. And J. Roman, of the ſame country, could carry the carcaſe of an ox. Vide Hakewill, ib. p. 238.

‘ Viros aliquot moderna memoria tam a mineralibus, quam aliis ‘ Suethiae et Gothiæ provinciis, adducere congruit, tanta fortitudine ‘ præditos, ut quiſque eorum in humeros ſublevatum equum, vel ‘ bovem maximum, imo vas ferri 600, 800, 1000 librarum (quale ‘ et aliquæ puellæ levare poſſunt,) ad plura ſtadia portaret.’ Ol. Mag. ubi ſupra.

haps have been made of ſufficient ſtrength to have barricaded our houſes; and walls and ramparts might perhaps have been made ſtrong enough to have fenced our cities. But theſe things could not have been without a great inconvenient expence of room, materials, and ſuch neceſſaries, as ſuch vaſt ſtructures and uſes would have occaſioned; more perhaps than the world could have afforded to all ages and places. But let us take the deſcant of a good naturaliſt and phyſician on the caſe[e]. 'Had man been a dwarf, 'ſaid he, he had ſcarce been a reaſonable crea- 'ture: for he muſt then have a jolt head; ſo 'there would not have been body and blood 'enough to ſupply his brain with ſpirits; or he 'muſt have had a ſmall head, anſwerable to his 'body, and ſo there would not have been brain 'enough for his buſineſs.—Or had the ſpecies of 'mankind been gigantic, he could not have 'been ſo commodiouſly ſupplied with food, 'for there would not have been fleſh enough 'of the beſt edible beaſts, to ſerve his turn. 'And if beaſts had been made anſwerably 'bigger, there would not have been graſs 'enough.' And ſo he goeth on. And a little after, 'There would not have been the 'ſame uſe and diſcovery of his reaſon; in that 'he would have done many things by mere

---

[e] Grew's Coſmol. Sacr. book 1. chap. 5, ſect. 25.

'ſtrength, for which he is now put to invent innumerable engines.—Neither could he have 'uſed an horſe, nor divers other creatures. But 'being of a middle bulk, he is fitted to manage 'and uſe them all. For, ſaith he, no other 'cauſe can be aſſigned, why a man was not made 'five or ten times bigger, but his relation to the 'reſt of the univerſe.' Thus far our curious author.

CHAP. V.

OF THE STRUCTURE OF THE PARTS OF MAN'S BODY.

HAVING thus taken a view of the poſture, ſhape, and ſize of man's body, let us in this chapter ſurvey the ſtructure of its parts. But here we have ſo large a proſpect, that it would be endleſs to proceed upon particulars. It muſt ſuffice therefore to take notice, in general only, how artificially every part of our body is made. No botch, no blunder, no unneceſſary apparatus, or in other words, no ſigns of chance[f]; but every thing curious, orderly, and performed in the ſhorteſt and beſt method, and adapted to the moſt compendious uſe. What one part is there throughout the whole body, but what is compoſed of the fitteſt matter for that part; made of the moſt proper ſtrength and texture; ſhaped in the completeſt form; and, in a word, accoutered with every thing neceſſary for its motion, office, nouriſhment, guard, and what not! What ſo commodious a ſtructure and texture could have been given to the bones, for inſtance, to make them firm and ſtrong, and withal light, as that which every bone in the body hath! Who could have ſhaped them ſo nicely to every uſe, and adapted them to every part, made them of ſuch juſt lengths, given them ſuch due ſizes and ſhapes, channelled, hollowed, headed, lubricated, and every other thing miniſtering, in the beſt and moſt compendious manner, to their ſeveral places and uſes! What a glorious collection and combination have we alſo of the moſt exquiſite workmanſhip and contrivance in the eye, in the ear, in the hand [g], in the foot [h], in lungs, and other parts already mentioned! What an abridgement of art, what a variety of uſes[i] hath nature laid upon that one member the tongue, the grand inſtrument of taſte, the faithful judge, the centinel, the watchman of all our nouriſhment, the artful modulator of our voice, the neceſſary ſervant of maſtication, ſwallowing, ſucking, and a great deal beſides! But I muſt deſiſt from proceeding upon particulars, finding I am fallen upon what I propoſed to avoid.

---

[f] It is manifeſtly an argument of deſign, that in the bodies of different animals, there is an agreement of the parts, ſo far as the occaſions and offices agree; but a difference of thoſe, where there is a difference of theſe. In an human body are many parts agreeing with thoſe of a dog, for inſtance; but in his forehead, fingers, hands, inſtruments of ſpeech, and many other parts, there are muſcles, and other members which are not in a dog: and ſo contrariwiſe in a dog, which are not in a man. If the reader is minded to ſee what particular muſcles are in a man, that are not in a dog, or in a dog, that are not in a human body, let him conſult the curious and accurate anatomiſt, Dr. Douglaſs's Myogr. compar.

---

[g] Galen having deſcribed the muſcles, tendons, and other parts of the fingers, and their motions, cries out, 'Conſidera igitur etiam 'hic mirabilem Creatoris ſapientiam!' De uſu Part. l. 1. c. 18.

[h] And not only in the hand, but in his account of the foot, l. 3. he frequently takes notice of what he calls, 'Artem, providentiam, 'et ſapientiam conditoris.' As chap. 13. 'An igitur non æquum eſt 'hic quoque admirari providentiam conditoris, qui ad utrumque uſum

And therefore, for a cloſe of this chapter, I ſhall only add part of a letter I received from the before commended very curious and ingenious phyſician, Dr. Tancred Robinſon: 'What ſaith 'he, can poſſibly be better contrived for animal

'motion

'uſum etſi certe contrarium, exacte convenientes et conſentientes 'invicem fabricatus eſt totius membri [tibiæ] particulas?' And at the end of the chapter, 'Quod ſi omnia quæ ipſarum ſunt partium 'mente immutaverimus, neque invenerimus poſitionem aliam meli-'orem ea quam nunc ſortita ſunt, neque figuram, neque magni-'tudinem, neque connexionem, neque (ut paucis omnia com-'plectar) aliud quidquam eorum, quæ corporibus neceſſario inſunt, 'perfectiſſimam pronunciare oportet, et undique recte conſtitutam præſentem ejus conſtructionem.' The like alſo concludes chap. 15.

[i] 'At enim opificis induſtrii maximum eſt indicium (quemadmo-'dum ante ſæpenumero jam diximus) iis quæ ad alium uſum 'fuerunt comparata, ad alias quoque utilitates abuti, neque laborare 'ut ſingulis utilitatibus ſingulas faciat proprias particulas.' Galen. ubi ſupra, l. 9. c. 5.

'motion and life, than the quick circulation of 'the blood and fluids, which run out of ſight in 'capillary veſſels, and very minute ducts, with'out impediment, except in ſome diſeaſes, being 'all directed to their peculiar glands and chan'nels, for the different ſecretion, ſenſible 'and inſenſible; whereof the laſt is far the 'greateſt in quantity and effects, as to health 'and ſickneſs, acute diſtempers frequently ariſing 'from a diminution of tranſpiration, through the 'cutaneous chimneys, and ſome chronical ones, 'from an augmentation; whereas, obſtructions 'in the liver, pancreas, and other glands, may 'only cauſe a ſchirrus, a jaundice, an ague, a 'dropſy, or other ſlow diſeaſes. So an increaſe 'of that ſecretion may accompany the general 'colliquations, as in fluxes, hectic ſweats and 'coughs, diabetes, and other conſumptions. 'What a mighty contrivance is there to preſerve 'theſe due ſecretions from the blood, (on which 'life ſo much depends,) by frequent attritions, 'and communications of the fluids in their paſ'ſage through the heart, the lungs and the 'whole ſyſtem of the muſcles! What maeanders 'and contortions of veſſels in the organs of 'ſeparation! And, what a concourſe of elaſtic 'bodies from the air, to ſupply the ſprings, and 'continual motions of ſome parts, not only in

'ſleep and reſt, but in long violent exerciſes of
'the muſcles! Whoſe force drives the fluids
'round in a wonderful rapid circulation through
'the minuteſt tubes, aſſiſted by the conſtant
'pabulum of the atmoſphere, and their own
'elaſtic fibres, which impreſs that velocity on
'the fluids.

'Now, I have mentioned ſome uſes of the air,
'in carrying on ſeveral functions in animal bo-
'dies; I may add the ſhare it hath in all the di-
'geſtions of the ſolid and fluid parts. For
'when this ſyſtem of air comes, by divine per-
'mittance, to be corrupted with poiſonous, ac-
'rimonious ſteams, either from the earth, from
'merchandiſe, or infected bodies, what havoc
'is made in all the operations of living creatures?
'The parts gangrene, and mortify under car-
'buncles, and other tokens: indeed, the whole
'animal oeconomy is ruined; of ſuch import-
'ance is the air to all the parts of it.' Thus my
learned friend.

CHAP. VI.

OF THE PLACING THE PARTS OF MAN'S BODY.

IN this chapter I propoſe to conſider the logement of the curious parts of man's body, which is no leſs admirable than the parts themſelves, all ſet in the moſt convenient places of the body, to miniſter to their own ſeveral uſes and purpoſes, and aſſiſt, and mutually to help one another. Where could thoſe faithful watchmen the eye, the ear, the tongue, be ſo commodiouſly placed, as in the upper part of the building? Where could we, throughout the body, find ſo proper a part to lodge four of the ſenſes, as in the head[k], near the brain[l], the common ſenſory, a place well guarded, and of little other uſe than to be a ſeat to thoſe ſenſes? And, how could we lodge the fifth ſenſe, that of touching, otherwiſe[m], than to diſperſe it to all parts of the body! Where could we plant the hand[n], but juſt where it is, to be ready at every turn, on all occaſions of help and defence, of motion, action, and every of its uſeful ſervices! Where could we ſet the legs and feet, but where they are, to bear up and handſomely to carry about the body! Where could we lodge the heart, to labour about the whole maſs of blood, but in, or near the centre of the body[o]! Where could we find room for that noble engine to play freely in! Where could we ſo well guard it againſt external harms, as it is in that very place in which it is lodged and ſecured! Where could we more commodiouſly place, than in the thorax and belly, the uſeful

---

[k] 'Senſus, interpretes ac nuntii rerum, in capite, tanquam in 'arce, mirifice ad uſus neceſſarios et facti, collocati ſunt. Nam 'oculi tanquam ſpeculatores, altiſſimum locum obtinent; ex quo 'plurima conſpicientes, fungantur ſuo munere. Et aures cum 'ſonum recipere debeant, qui natura in ſublime fertur; recte in illis 'corporum partibus collocatæ ſunt.' Cicer. de Nat. Deor. l. 2. c. 56. ubi plura de cæteris ſenſibus.

[l] Galen well obſerves, that the nerves miniſtring to motion, are hard and firm, to be leſs ſubject to injury; but thoſe miniſtring to ſenſe

---

ſenſe, are ſoft and tender; and that for this reaſon it is, that four of the five ſenſes are lodged ſo near the brain, viz. partly to partake of the brain's ſoftneſs and tenderneſs, and partly for the ſake of the ſtrong guard of the ſkull. Vide Gal. de uſu Part. l. 8. c. 5, 6.

[m] See book iv. chap. 6. note (*a*) 201.

[n] 'Quam vero aptas, quamque multarum artium miniſtras manus 'natura homini dedit!' The particulars of which, enumerated by him, ſee in Cic. ubi ſupra, c. 60.

[o] See book vi. chap. 5.

uſeful viſcera of thoſe parts, ſo as not to ſwag and jog, and over-ſet the body, and yet to miniſter ſo harmoniouſly as they do, to all the ſeveral uſes of concoction, ſanguification, the ſeparation of various ferments from the blood, for the great uſes of nature, and to make diſcharges of what is uſeleſs, or would be burdenſome or pernicious to the body[p]! How could we plant the curious and great variety of bones, and of muſcles, of all ſorts and ſizes, neceſſary, as I have ſaid, to the ſupport, and every motion of the body! Where could we lodge all the arteries and veins, to convey nouriſhment; and the nerves, ſenſation throughout the body! Where, I ſay, could we lodge all thoſe implements of the body, to perform their ſeveral offices! How could we ſecure and guard them ſo well, as in the very places, and in the ſelf-ſame manner in which they are already placed in the body! And laſtly, to name no more, what covering, what fence could we find out for the whole body, better than that of nature's own providing, the ſkin[q]! How could we ſhape it to, or brace it about every part better, either for convenience or ornament! What better texture could we give it, which although leſs obdurate and firm, than that of ſome other animal; yet is ſo much the more ſenſible of every touch, and more compliant with every motion? And being eaſily defenſible by the power of man's reaſon and art, is therefore much the propereſt tegument for a reaſonable creature.

---

[p] ‘Ut in ædificiis architecti avertunt ab oculis et naribus dominorum ea, quæ profluentia neceſſario tetri eſſent aliquid habitura; ſic natura res ſimiles, ſcil. excrementa, procul amandavit a ſenſibus.’ Cic. de Nat. Deor. l. 2. c. 56.

[q] Compare here Galen's obſervations De Uſu Bart. l. 11. c. 15. See alſo Cowper, Anat. where in tab. 4. are very elegant cuts of

the ſkin in divers parts of the body, drawn from microſcopical views; as alſo of the papillæ pyramidales, the ſudoriferous glands, and veſſels, the hairs, &c.

CHAP. VII.

OF THE PROVISION IN MAN'S BODY AGAINST EVILS.

HAVING taken a tranſient view of the ſtructure and logement of the parts of the human bodies; let us next conſider the admirable proviſion that is made throughout man's body, to ſtave off evils, and to diſcharge[r] them when befallen. For the prevention of evils, we may take the inſtances already given, of the ſituation of thoſe faithful centinels, the eye, the ear, and tongue, in the ſuperior part of the body, the better to deſcry dangers at a diſtance, and to call out preſently for help. And how well ſituated is the hand to be a ſure and ready guard to the body,

---

[r] One of nature's moſt conſtant methods here, is by the glands, and the ſecretions made by them; the particulars of which being too long for theſe notes, I ſhall refer to the modern anatomiſts, who have written on theſe ſubjects; and indeed, who are the only men that have done it tolerably: particularly our learned doctors Cockburn, Keil, Morland, and others at home and abroad; an abridgement of whoſe opinions and obſervations, for the reader's eaſe, may be met with in Dr. Harris's Lex. Tech. vol. 2. under the words Glands, and Animal Secretion.

body, as well as the faithful performer of moſt of its ſervices! The brain, the nerves, the arteries, the heart[s], the lungs; and, in a word, all the principal parts, how well are they barricaded, either with ſtrong bones, or deep logements in the fleſh, or ſome ſuch the wiſeſt and fitteſt method, moſt agreeable to the office and action of the part? Beſides which, for greater precaution, and a farther ſecurity, what an incomparable proviſion hath the infinite contriver of man's body made for the loſs of, or any defect in, ſome of the parts we can leaſt ſpare, by doubling them; By giving us two eyes, two ears, two hands, two kidneys, two lobes of the lungs, pairs of the nerves, and many ramifications of the arteries and veins in the fleſhy parts, that there may not be a defect of nouriſhment of the parts, in caſes of amputation, or wounds, or ruptures of any of the veſſels.

And as man's body is admirably contrived, and made to prevent evils; ſo no leſs art and caution hath been uſed to get rid of them, when they do happen. When by any misfortune, wounds or hurts do befal; or, when by our own wicked fooleries and vices, we pull down diſeaſes and miſchiefs upon ourſelves, what emunctories[t], what admirable paſſages[u], are diſperſed throughout the body; what incomparable methods doth nature take [v]; what vigorous efforts is ſhe enabled to make, to diſcharge the peccant humour, to correct the morbific matter; and, in a word, to ſet all things right again? But here we had beſt take the advice of a learned phyſician in the caſe: ‘The body, ſaith he, is ſo contrived, as to be well enough ſecured againſt the mutations in the air, and the leſſer errors we daily run upon; did we not in the exceſſes of eating, drinking, thinking, loving, hating, or ſome other folly, let in the enemy, or lay violent hands upon ourſelves. Nor is the body fitted only to prevent, but alſo to cure, or mitigate diſeaſes, when by theſe follies brought upon us. In moſt wounds, if kept clean, and from the air,—the fleſh will glew together with its own native balm. Broken bones are cemented with the callus, which themſelves help to make.’ And ſo he goes on with ample inſtances in this matter, too many to be here ſpecified [w]. Among which he inſtanceth in the diſtempers of our bodies, ſhewing, that even many of them are highly ſerviceable to the diſcharge of

---

[s] In man, and moſt other animals, the heart hath the guard of bones; but in the lamprey, which hath no bones, (no not ſo much as a back-bone,) 'the heart is very ſtrangely ſecured, and lies immured, or capſulated in a cartilage, or griſly ſubſtance, which includes the heart, and its auricle, as the ſkull doth the brain in other animals.' Power's Microſ. obſ. 22.

---

[t] 'Here [from the poſtules he obſerved in Monomotapa] were 'grounds to admire the contrivance of our blood, which, on ſome 'occaſions, ſo ſoon as any thing deſtructive to the conſtitution of it 'comes into it, immediately by an inteſtine commotion, endeavour-'eth to thruſt it forth, and is not only freed from the new gueſt; 'but ſometimes what likewiſe may have lain lurking therein—for a 'great while. And from hence it comes to paſs, that moſt parts of 'medicines, when duly adminiſtered, are not only ſent out of the 'body themſelves; but likewiſe great quantities of morbific matter; 'as in ſalivation,' &c. Dr. Sloane's Voy. to Jamaica, p. 25.

[u] Valſalva diſcovered ſome paſſages into the region of the ear-drum, of mighty uſe; among others, to make diſcharges of bruiſes, impoſthumes, or any purulent, or morbific matter from the brain, and parts of the head. Of which he gives two examples: one a perſon, who, from a blow on his head, had diſmal pains therein, grew ſpeechleſs, and lay under an abſolute ſuppreſſion and decay of his ſtrength; but found certain relief, whenever he had a flux of blood, or purulent matter out of his ear; which after his death Valſalva diſcovered was through thoſe paſſages.

The other was an apoplectical caſe, wherein he found a large quantity of extravaſated blood, making way from the ventricles of the brain, through thoſe ſame paſſages. Valſal. de Aure hum. c. 2. ſect. 14. and c. 5. ſect. 8.

---

[v] Hippocrates, Lib. de Alimentis, takes notice of the ſagacity of nature, in finding out methods and paſſages for the diſcharging things offenſive to the body, of which the late learned and ingenious biſhop of Clogher, in Ireland, (Boyle,) gave this remarkable inſtance, to my very curious and ingenious neighbour and friend, D'Acre Barret, Eſq. viz. that in the plague-year, a gentleman at the univerſity had a large plague-ſore gathered under his arm, which, when they expected it would have broken, diſcharged itſelf by a more than ordinary large and foetid ſtool; the ſore having no other vent for it, and immediately becoming ſound and well thereon.

Like to which, is the ſtory of Joſ. Lazonius, of a ſoldier of thirty-five years of age, who had a ſwelling in his right hip, accompanied with great pain, &c. By the uſe of emollient medicines, having ripened the ſore, the ſurgeon intended the next day to have opened it; but about midnight, the patient having great provocations to ſtool, diſburdened himſelf three times; immediately upon which, both the tumour and pain ceaſed, and thereby diſappointed the ſurgeon's intentions. Ephem. Germ. Anno 1690. obſ. 49. More ſuch inſtances we find of Mr. Tonge's, in Phil. Tranſ. No. 323. But indeed there are ſo many examples of this nature, in our Phil. Tranſ. in Ephem. German. Tho. Bartholine; Rhodius, Sennertus, Hildanus, &c. that it would be endleſs to recount them. Some have ſwallowed knives, bodkins, and pins, bullets, pebbles, and twenty other ſuch things as could not find a paſſage the ordinary way, but have met with an exit through the bladder, or ſome other way of nature's own providing. But paſſing over many particulars, I ſhall only give one inſtance more, becauſe it may be a good caution to ſome perſons, that theſe papers may probably fall into the hands of, and that is, the danger of ſwallowing plumb-ſtones, prune-ſtones, &c. Sir Francis Butler's lady had many prune ſtones that made way through an abſceſs near her navel. Phil. Tranſ. No. 265. where are many other ſuch like examples. More alſo may be found in

No.

No. 282, 304, &c. And at this day a young man, living not far off me, laboureth under very troubleſome and dangerous ſymptoms, from the ſtones of ſloes and bullace, which he ſwallowed eight or ten years ago.

[w] Grew's Coſmol. ſect. 28, 29.

of malignant humours, and preventing greater evils.

And no leſs kind than admirable is this contrivance of man's body, that even its diſtempers ſhould many times be its cure[x]; that when the enemy lies lurking within to deſtroy us, there ſhould be ſuch a reluctancy, and all nature excited with its utmoſt vigour to expel him thence. To which purpoſe, even pain itſelf is of great and excellent uſe, not only in giving us notice of the preſence of the enemy, but by exciting us to uſe our utmoſt diligence and ſkill to root out ſo troubleſome and deſtructive a companion.

---

[x] 'Nor are diſeaſes themſelves uſeleſs: for the blood in a fever, 'if well governed, like wine upon the fret, diſchargeth itſelf of all 'heterogeneous mixtures; and nature, the diſeaſe, and remedies, 'clean all the rooms of the houſe; whereby that which threatens 'death, tends, in concluſion, to the prolonging of life.' Grew, ubi ſupra, ſect. 52.

And as diſeaſes miniſter ſometimes to health; ſo to other good uſes in the body, ſuch as quickening the ſenſes: of which take theſe inſtances relating to the hearing and ſight.

'A very ingenious phyſician falling into an odd kind of fever, had 'his ſenſe of hearing thereby made ſo very nice and tender, that he 'very plainly heard ſoft whiſpers, that were made at a conſiderable 'diſtance off, and which were not in the leaſt perceived by the byſtanders, nor would have been by him before his ſickneſs.

'A gentleman of eminent parts and note, during a diſtemper he 'had in his eyes, had his organs of ſight brought to be ſo tender, 'that both his friends, and himſelf have aſſured me, that when he 'walked in the night, he could for a while plainly ſee and diſtinguiſh colours, as well as other objects, diſcernible by the eye, as 'was more than once tried.' Boyl. deter. nat. of Effluv. chap. 4.

'Daniel Fraſer—continued deaf and dumb from his birth, till 'the 17th year of his age—After his recovery from a fever, he perceived a motion in his brain, which was very uneaſy to him; 'and afterwards he began to hear, and in proceſs of time, to underſtand ſpeech,' &c. Vide Phil. Tranſ. No. 312.

CHAP. VIII.

OF THE CONSENT BETWEEN THE PARTS OF MAN'S BODY.

IT is an admirable proviſion the merciful Creator hath made for the good of man's body, by the conſent and harmony between the parts thereof: of which let us take St. Paul's deſcription, in 1 Cor. xii. 8. 'But now hath God ſet 'the members, every one of them in the body, 'as it hath pleaſed him.' And ver. 21. 'The 'eye cannot ſay unto the hand, I have no need 'of thee: nor again, the head to the feet, I 'have no need of you.' But ſuch is the conſent of all the parts, or, as the apoſtle wordeth it, 'God hath ſo tempered the body together, that 'the members ſhould have the ſame care one for 'another,' ver. 25. 'So that whether one member ſuffer, all the members ſuffer with it; or 'one member be honoured, (or affected with any 'good,) all the members rejoice, [and ſympathize] with it,' ver. 26.

This mutual accord, conſent, and ſympathy of the members, there is no reaſon to doubt[y], is made by the commerce of the nerves[z], and their artificial poſitions, and curious ramifications throughout the whole body, which is admirable and incomparable, and might deſerve a place in this ſurvey, as greatly, and manifeſtly ſetting forth the wiſdom and benignity of the great Creator; but that to give a deſcription thereof from the origin of the nerves, in the brain, the cerebellum and ſpine, and ſo through every part of the body, would be tedious, and intrench too much upon the anatomiſt's province: and therefore one inſtance ſhall ſuffice for a ſample of the whole; and that ſhall be, (what was promiſed before)[a], the great ſympathy occaſioned by the fifth pair of nerves; which I chuſe to inſtance in, rather than the par vagum, or any other of the nerves; becauſe although we may have leſs variety of noble contrivance and art, than in that pair; yet we ſhall find enough for our purpoſe, and which may be diſpatched in fewer words. Now, this fifth conjugation of nerves is branched to the ball, the muſcles, and glands of the eye; to the ear; to the jaws, the gums, and teeth; to the muſcles of the lips[b]; to the tonſils, the palate, the tongue, and parts of the mouth; to the praecordia alſo, in ſome meaſure, by inoſculating with one of its nerves; and laſtly, to the muſcles of the face, particularly the cheeks, whoſe ſanguiferous veſſels it twiſts about.

---

[y] See book iv. chap. 8.

[z] 'Tria propoſita ipſi naturæ in nervorum diſtributione fuerunt. 1. Ut ſenſoriis inſtrumentis ſenſum impertiret. 2. Ut motoriis motum. 3. Ut omnibus aliis [partibus] daret ut quæ, ſi dolorem adferrent, dignoſcerent.' And afterwards, 'Si quis in diſſectionibus ſpectavit, conſideravitque juſtene an ſecus natura nervos non eadem menſura omnibus partibus diſtribuerit, ſed aliis quidem liberalius, aliis vero parcius, eadem cum Hippocrate, velit nolit, de natura omnino pronunciabit, quod ea ſcilicet ſagax, juſta, artificioſa, animaliumque provida eſt.' Galen. de uſu Part. l. 5. c. 9.

[a] Book iv. chap. 5.

From hence it comes to paſs, that there is a great conſent and ſympathy[c] between theſe parts; ſo that a guſtable thing ſeen or ſmelt, excites the appetite, and affects the glands and parts of the mouth; that a thing ſeen or heard, that is ſhameful, affects the cheeks with modeſt bluſhes; but on the contrary, if it pleaſes and tickles the fancy, that it affects the præcordia and muſcles of the mouth and face with laughter; but a thing cauſing ſadneſs and melancholy, doth accordingly exert itſelf upon the præcordia, and demonſtrate itſelf by cauſing the glands of the eyes to emit tears [d], and the muſcles of the face to put on the ſorrowful aſpect of crying. Hence alſo that torvous ſour look produced by anger and hatred; and that gay and pleaſing countenance accompanying love and hope. And in ſhort, it is by means of this communication of the nerves, that whatever affects the ſoul is demonſtrated, whether we will or no, by a conſentaneous diſpoſition of the præcordia within, and a ſuitable configuration of the muſcles and parts of the face without. And an admirable contrivance of the great God of nature this is; that as a face

---

[b] Dr. Willis gives the reaſon, 'Cur mutua amaſiorum oſcula 'labiis impreſſa, tum præcordia, tum genitalia afficiendo, amorem 'ac libidinem tam facile irritant,' to be from the conſent of thoſe parts, by the branches of this fifth pair. Nerv. Deſcr. c. 22.

And Dr. Sachs judges it to be from the conſent of the 'labia oris 'cum labiis uteri,' that in April 1699, a certain breeding lady, being affrighted with ſeeing one that had ſcabby lips, which they told her were occaſioned by a peſtilential fever, had ſuch like puſtules broke out in the labia uteri. Ephem. Germ. T. 1. obſ. 20.

[c] Conſult Willis, ubi ſupra.

---

[d] Tears ſerve not only to moiſten the eye, to clean and brighten the coruea, and to expreſs our grief; but alſo to alleviate it, according to that of Ulyſſes to Andiomache, in Seneca's Troas, ver. 762,

> Tempus moramque dabimus, arbitrio tuo
> Implere lacrymis: Fletus ærumnas levat,

a face is given to man, and as Pliny ſaith[e], to man alone of all creatures; ſo it ſhould be, as he obſerves, ‘the index of ſorrow and chearfulneſs, ‘of compaſſion and ſeverity. In its aſcending ‘part is the brow, and therein a part of the ‘mind too. Therewith we deny, therewith we ‘conſent. With this it is we ſhew our pride, ‘which hath its ſource in another place; but ‘here its ſeat: in the heart it hath its birth; but ‘here it abides and dwells; and that becauſe it ‘could find no other part throughout the body ‘higher, or more craggy[f], where it might re‘ſide alone.’

Thus I have diſpatched what I ſhall remark concerning the ſoul and body of man. There are divers other things, which well deſerves a place in this ſurvey; and theſe that I have taken notice of, deſerved to have been enlarged upon; but what hath been ſaid may ſuffice for a taſte and ſample of this admirable piece of God's handy-work; at leaſt ſerve as a ſupplement to what others have ſaid before me. For which reaſon I have endeavoured to ſay as little wittingly as I could, of what they have taken notice of, except where the thread of my diſcourſe laid a neceſſity upon me.

---

[e] Plin. Nat. Hiſt. l. 11. c. 37.

[f] ‘Nihil altius ſimul abruptiuſque invenit.’

CHAP. IX.

OF THE VARIETY OF MEN'S FACES, VOICES, AND HAND-WRITING.

HERE I. would have put an end to my obſervations relating to man; but that there are three things ſo expreſly declaring the divine management and·concurrence, that I ſhall but juſt mention them, although taken notice of more amply by others; and that is, the great variety throughout the world, of mens faces[g], voices[h], and

---

[g] If the reader hath a mind to ſee examples of men's likeneſs, he may conſult Valer. Maximus, l. 9. c. 14. concerning the likeneſs of Pompey the great, and Vibius, and Publicius Libertinus; as alſo of Pompey the father, who got the name of Coquus, he being like Menogenes the cook; with divers others.

[h] As the difference of tone makes a difference between every man's voice, of the ſame country, yea, family, ſo a different dialect and pronunciation differs perſons of divers countries, yea, perſons of one and the ſame country, ſpeaking the ſame language: thus in Greece, there were the Ionic, Doric, Attic, and Æolic dialects. So in Great Britain, beſides the grand diverſity of Engliſh and Scots, the different counties vary very much in the pronunciation, accent,

and hand-writing. Had man's body been made according to any of the atheiſtical ſchemes, or any other method than that of the infinite Lord of the world, this wiſe variety would never have been: but mens faces would have been caſt in the ſame, or not a very different mould; their organs of ſpeech would have ſounded the ſame, or not ſo great a variety of notes; and the ſame ſtructure of muſcles and nerves would have given the hand the ſame direction in writing. And in this caſe, what confuſion, what diſturbance, what miſchiefs, would the world eternally have lain under! No ſecurity could have been to our perſons: no certainty, no enjoyment of our poſſeſſions[i]; no juſtice between man and man;

no

---

and tone, although all one and the ſame language. And the way of the Gileadites proving the Ephraimites, Judges xii. 6. by the pronunciation of Shibboleth, with a Schin, or Sibboleth with a Samech, is well known. So a Lapide ſaith, the Flemings prove whether a man be a Frenchman or not, by bidding him pronounce Acht en tachtenticht; which they pronounce Act en tactentick, by reaſon they cannot pronounce the aſpirate.

[i] 'Regi Antiocho unus ex æqualibus—nomine Artemon, perquam ſimilis fuiſſe traditur. Quem Laodice, uxor Antiochi, interfecto viro, diſſimulandi ſceleris gratia, in lectulo perinde quaſi ipſum regem ægrum collocavit. Admiſſumque univerſum populum, et ſermone ejus et vultu conſimili fefellit: crediderunque homines ab Antiocho moriente Laodicen et natos ejus ſibi commendari.' Valer. Max. ib.

no diſtinction between good and bad, between friends and foes, between father and child, huſband and wife, male or female; but all would have been turned topſey-turvey, by being expoſed to the malice of the envious and ill-natured, to the fraud and violence of knaves and robbers, to the forgeries of the crafty cheat, to the luſts of the effeminate and debauched, and what not! Our courts of juſtice[k] can abundantly teſtify the dire effects of miſtaking mens faces, of counterfeiting their hands, and forging writings. But now, as the infinitely wiſe Creator and ruler hath ordered the matter, every man's face can diſtinguiſh him in the light, and his voice in the dark; his hand-writing can ſpeak for him though abſent, and be his witneſs, and ſecure his contracts in future generations. A manifeſt, as well as admirable indication of the divine ſuperintendence and management[l].

---

[k] ‘Quid Trebellius Calca! quam aſſeveranter ſeſe Clodium tulit! et quidem dum de bonis ejus contendit, in centumvirale judicium adeo favorabilis deſcendit, ut vix juſtis et æquis ſententiis conſternatio populi ullum relinqueret locum. In illa tamen quæſtione neque calumniæ petitoris neque violentiæ plebis judicantium religio ceſſit.’ Val. Max. lib. c. 15,

[l] To the foregoing inſtances of divine management, with relation to the political ſtate of man, I ſhall add another thing, that I confeſs hath always ſeemed to me ſomewhat odd, but very providential;

and that is, the value that mankind, at leaſt the civilized part of them, have in all ages put upon gems, and the purer finer metals, gold and ſilver; ſo as to think them equivalent unto, and exchange them for things of the greateſt uſe for food, cloathing, and all other neceſſaries and conveniences of life. Whereas thoſe things themſelves are of very little, if any uſe, in phyſic, food, building, or cloathing, otherwiſe than for ornament, or to miniſter to luxury; as Suetonius tells us of Nero, who fiſhed with a net gilt with gold, and ſhod his mules with ſilver; but his wife Poppaea ſhod her horſes with gold. Vit. Ner. c. 30. Plin. Nat. Hiſt. l. 33. c. 11. So the ſame Suetonius tells us, Jul. Cæſar lay in a bed of gold, and rode in a ſilver chariot. But Heliogabalus rode in one of gold, and had his cloſe-ſtool-pans of the ſame metal. And Pliny ſaith, 'Vaſa coquinaria ex argento Calvus orator fieri queritur.' Ibid. Neither are thoſe precious things of greater uſe to the making of veſſels and utenſils, (unleſs ſome little niceties and curioſities,) by means of their beauty, imperdibility, and ductility. Of which laſt, the great Mr. Boyle hath, among others, theſe two inſtances, in his Eſſay about the Subtilty of Effluviums, chap. 2. 'Silver, whoſe ductility and tractility are very much inferior to thoſe of gold, was, by my procuring, drawn out to ſo ſlender a wire, that—a ſingle grain of it amounted to twenty ſeven feet.' As to gold, he demonſtrates it poſſible to extend an ounce thereof to reach to 777600 feet, or 155 miles and an half, yea, to an incredibly greater length.

And as to gems, the very ſtories that are told of their prodigious virtues, are an argument, that they have very little, or none, more than other hard ſtones. That a diamond ſhould diſcover whether a woman be true or falſe to her huſband's bed; cauſe love between man and wife; ſecure againſt witchcraft, plague, and poiſons; that the ruby ſhould diſpoſe to chearfulneſs, cauſe pleaſant dreams, change its colour againſt a misfortune befalling, &c. that the ſapphire ſhould grow foul, and loſe its beauty, when worne by one that is leacherous; that the emerald ſhould fly to pieces, if it touch the ſkin of any unchaſte perſon in the act of uncleanneſs; that the chryſolite ſhould loſe its colour, if poiſon be on the table, and recover it again when the poiſon is off; and, to name no more, that the turcoiſe, and the ſame is ſaid of a gold ring, ſhould ſtrike the hour when hung over a drinking glaſs, and much more to the ſame purpoſe: all theſe, and many other ſuch fabulous ſtories, I ſay, of gems, are great arguments, that their virtue is equivalent to their value. Of theſe, and other virtues, conſult Wormius, in his Muſaeum, l. 1. ſect. 2. c. 17, &c.

But as to gems changing their colour, there may be ſomewhat of truth in that, particularly in the turcoiſe laſt mentioned. Mr. Boyle obſerved the ſpots in a turcoiſe, to ſhift their place from one part to another, by gentle degrees. So did the cloud in an agate-handle of a knife. A diamond he wore on his finger, he obſerved to be more illuſtrious at ſome times than others; which a curious lady told him ſhe had obſerved in hers. So likewiſe a rich ruby did the ſame. Boyl. of Abſol. Reſt in Bodies.

C H A P. X.

THE CONCLUSION OF THE SURVEY OF MAN.

AND now having taken a view of man, and finding every part of him, every thing relating to him contrived, and made in the very beſt manner; his body fitted up with the utmoſt foreſight, art, and care; and his body, (to the great honour, privilege, and benefit of man,) poſſeſſed by a divine part, the ſoul, a ſubſtance made, as it were, on purpoſe to contemplate the works of God, and glorify the great Creator; and ſince this ſoul can diſcern, think, reaſon, and ſpeak; what can we conclude upon the whole matter, but that we lie under all the obligations of duty and gratitude, to be thankful and obedient to, and to ſet forth the glories of our great Creator, and noble benefactor! And what ungrateful wretches are we, how much worſe than the poor irrationals, if we do not employ the utmoſt power of our tongue, and all our members, and all the faculties of our ſouls, in the praiſes of God! But above all, ſhould we who have the benefit of thoſe glorious acts and contrivances of the Creator, be ſuch wicked, ſuch baſe, ſuch worſe than brutal fools, to deny the Creator[m], in ſome of his nobleſt works?

---

[m] It was a pious, as well as juſt concluſion, the ingenious Laurence Bellini makes of his Opuſculum de Motu Cordis, in theſe words: 'De motu cordis iſthæc. Quæ equidem omnia, ſi a rudi 'intelligentia hominis tantum conſilii, tantum ratiocinii, tantum 'peritiæ mille rerum, tantum ſcientiarum exigunt, ad hoc, ut in'veniantur, ſeu ad hoc, ut percipiantur poſtquam facta ſunt; illum, 'cujus opera fabrefacta ſunt hæc ſingula, tam vani erimus atque 'inanes, ut exiſtimemus eſſe conſilii impotem, rationis expertem, 'imperitum, aut ignarum omnium rerum? Quantum ad me attinet, 'nolim eſſe rationis compos, ſi tantum inſudandum mihi eſſet ad 'conſequendum intelligentiam earum rerum, quas fabrefaceret 'neſcio quæ vis, quæ nihil intelligeret eorum quæ fabrefaceret; 'mihi etenim viderer eſſe vile quiddam, atque ridiculum, qui vel'lem, totam ætatem meam, ſanitatem, et quicquid humanum eſt 'deterere, nihil curare quicquid eſt jucunditatum, quicquid 'lætitiarum, quicquid commodorum; non divitias, non dignitates: 'non poenas etiam, et vitam ipſam, ut gloriari poſſem poſtremo in'veniſſe unum, aut alterum, et fortaſſe me inveniſſe quidem ex 'iis innumeris, quæ produxiſſet, neſcio quis ille, qui ſine labore, 'ſine cura, nihil cogitans, nihil cognoſcens, non unam aut alteram 'rem, neque dubie ſed certo produxiſſet innumeras innumerabili'tates rerum in hoc tam immenſo ſpatio corporum, ex quibus totus 'mundus compingitur. Ah Deum immortalem! Video præſens 'numen tuum in hiſce tam prodigioſis generationis initiis et in altiſ'ſima eorum contemplatione defixus, neſcio quo oeſtro admira'tionis conciter, et quaſi divine furens cohibere me minime poſſum 'quin exclamem.

Should we ſo abuſe our reaſon, yea, our very ſenſes! ſhould we be ſo beſotted by the devil, and blinded by our luſts, as to attribute one of the beſt contrived pieces of workmanſhip to blind chance, or unguided matter and motion, or any other ſuch ſottiſh, wretched, atheiſtical ſtuff; which we never ſaw, nor ever heard made any one being[n] in any age ſince the creation! No, no! But, like wiſe and unprejudiced men, let us with David ſay, Pſalm cxxxix. 14. with which I conclude, ‘I will praiſe thee, for I am fearfully and wonderfully made; marvellous are thy works, and that my ſoul knoweth right well.’

‘Magnus Dominus! Magnus fabricator hominum Deus! Magnus atque admirabilis! Conditor rerum Deus, quam magnus es!’ Bellin. de Mot. Cord. fin.

[n] ‘Hoc [i. e. mundum effici ornatiſſimum, et pulcherrimum ex concurſione fortuita] qui exiſtimat fieri potuiſſe, non intelligo cur non idem putet, ſi innumerabiles unius, et viginti formae literarum, vel aureae, vel qualiſlibet, aliquo conjiciantur, poſſe ex his in terram excuſſis annales Ennij ut deinceps legi poſſint, effici, &c.——Quod ſi mundum efficere poteſt concurſus atomorum, cur porticum, cur templum, cur domum, cur urbem, non poteſt? Quae ſunt minus operoſa, et multo quidem faciliora.’ Cic. de Nat. Deor. l. 2. c. 37.

Having thus made what (conſidering the copiouſneſs and excellence of th ſubject,) may be called a very brief ſurvey of man, and ſeen ſuch admirable marks of the divine deſign and art; let us next take a tranſient view of the other inferior creatures; and begin with quadrupeds.

END OF VOL. I.